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Compressed air

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Compressed Air Magazine

Vol. XXVI, No. VII London New York Paris 35 Cents a Copy

JULY, 1921

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ANACONDA HILL IN THE BUTTE MINING DISTRICT COMMONLY KNOWN AS THE "RICHEST COPPER HILL IN THE WORLD."

Modern Development in Manufacture of Building Glass
Robert G. Skerrett

Rill Stoping in the Butte District
H. L. Bicknell

Pneumatic Caisson Foundations for Tall Buildings
Frank W. Skinner

Lubricating Compressor Cylinders and Bearings
H. Mooney

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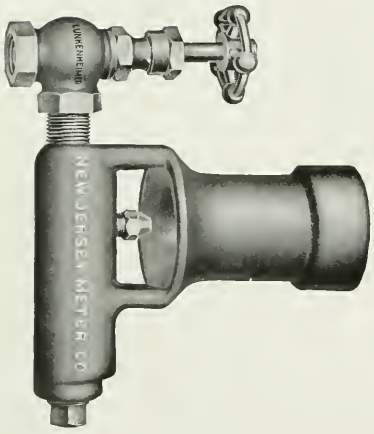

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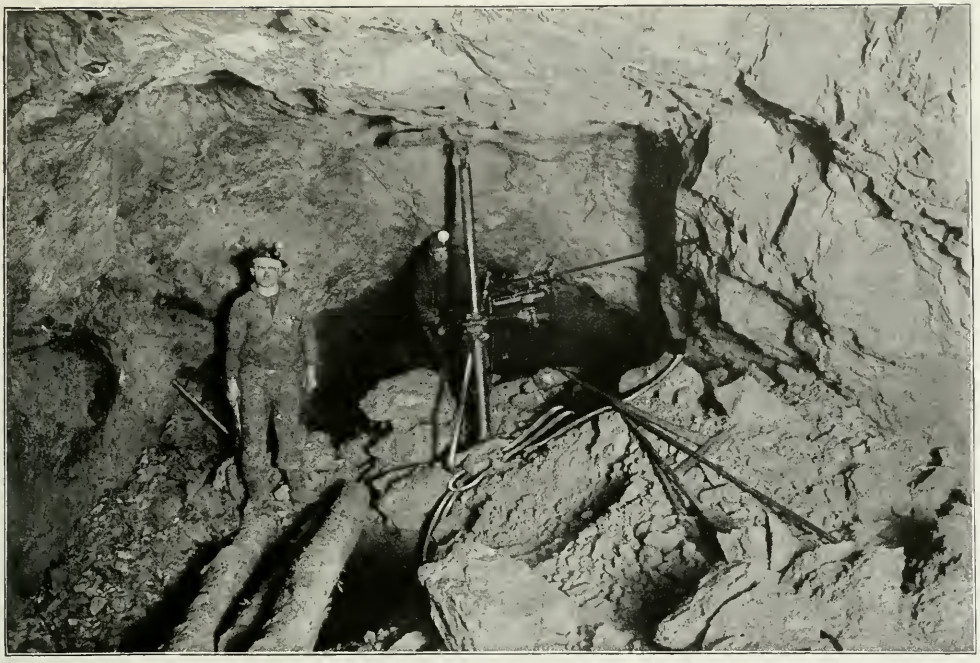

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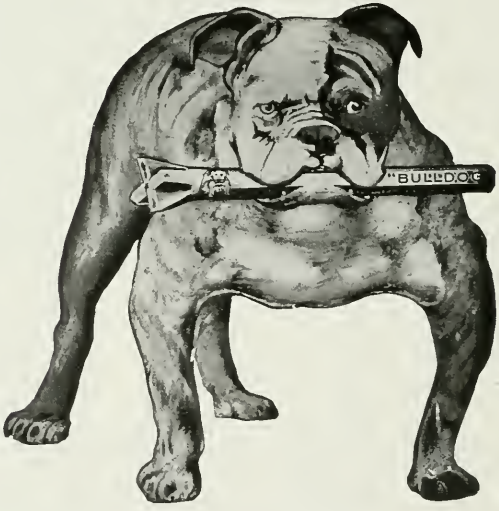

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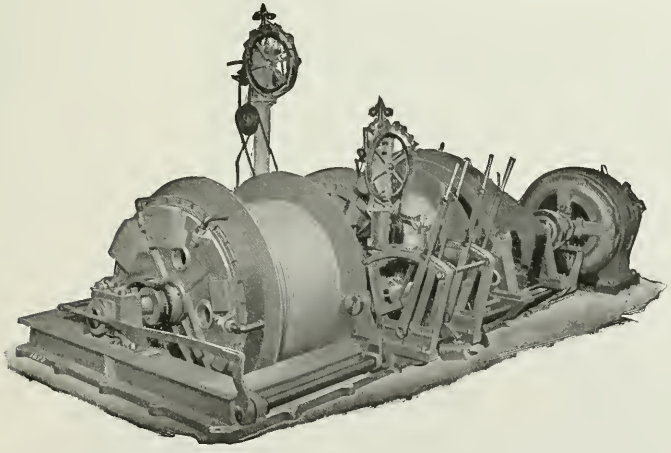

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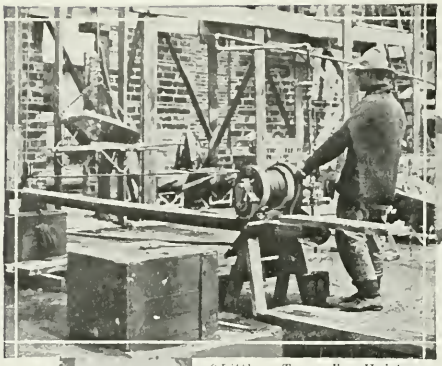

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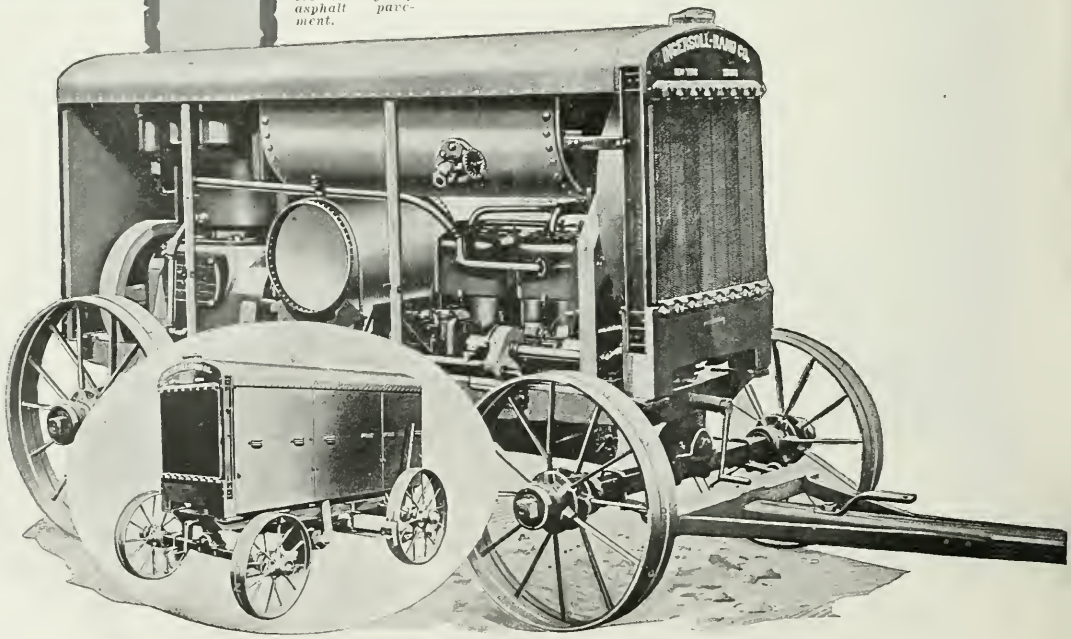

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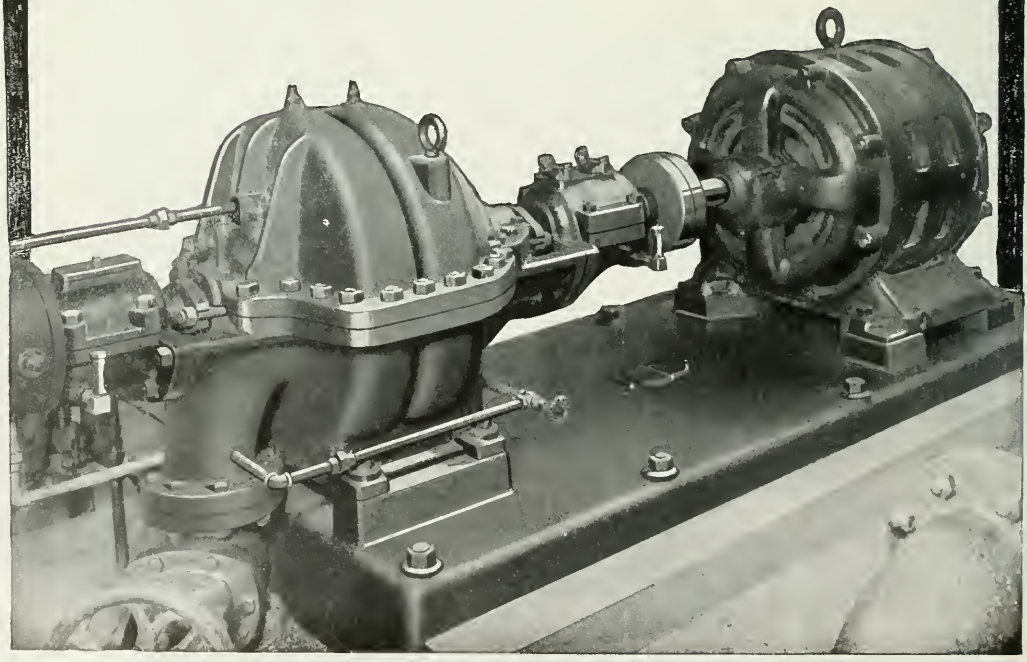

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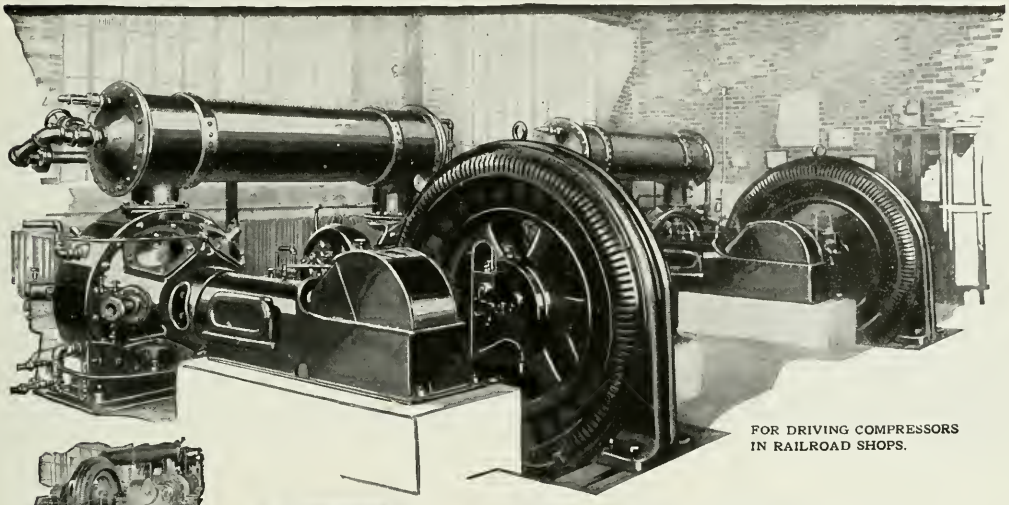
The proper use of synchronous motors will increase the power available for production without increasing the power bill



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A prominent factor in Steel production.

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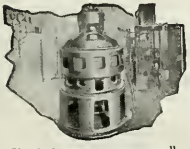
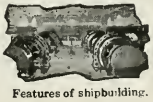


Vertical type — on deep well water pump at packing plant.

Driving triplex pumps in concentration mill of a copper company.

And for driving refrigerating machines.



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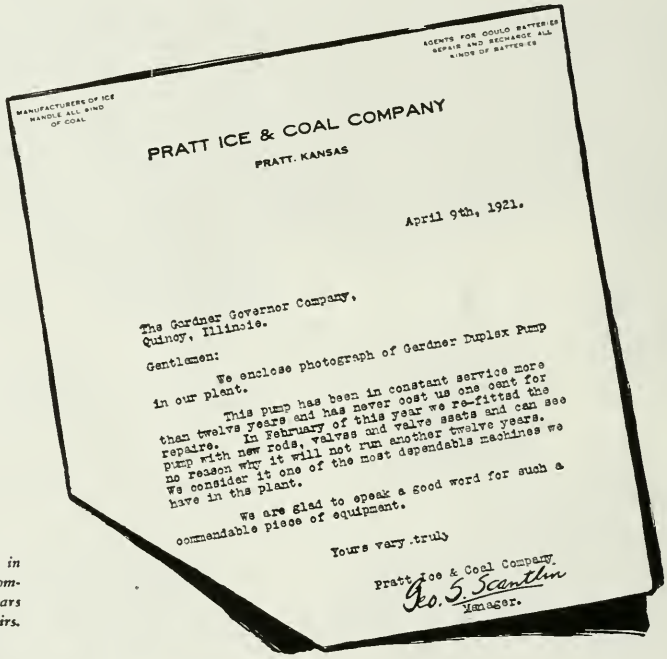

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AGENTS FOR GOULD BATTERIES
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PRATT, KANSAS

April 9th, 1921.

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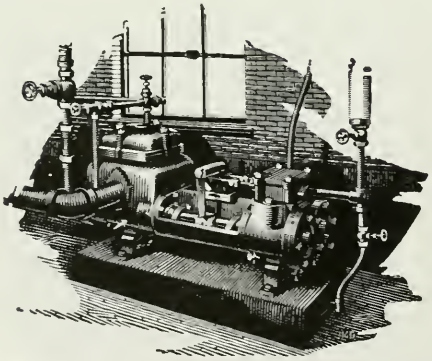
This pump has been in constant service more than twelve years and has never cost us one cent for repairs. In February of this year we re-fitted the pump with new rods, valves and valve seats and can see no reason why it will not run another twelve years. We consider it one of the most dependable machines we have in the plant.

We are glad to speak a good word for such a commendable piece of equipment.

Yours very truly

Pratt Ice & Coal Company.
Geo. S. Scantlin
Manager.

Gardner Duplex Steam Pump in plant of Pratt Ice & Coal Company, Pratt, Kans. Twelve years of service—not one cent for repairs.



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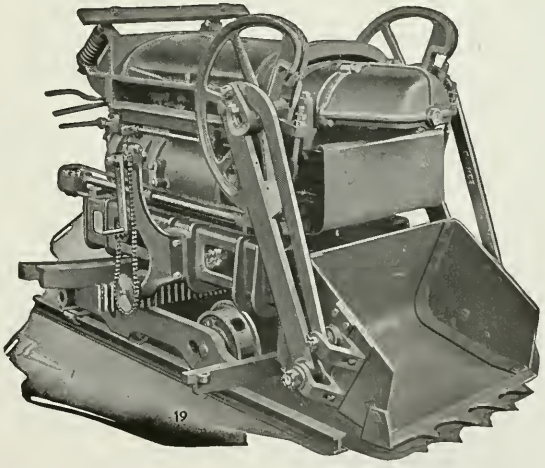

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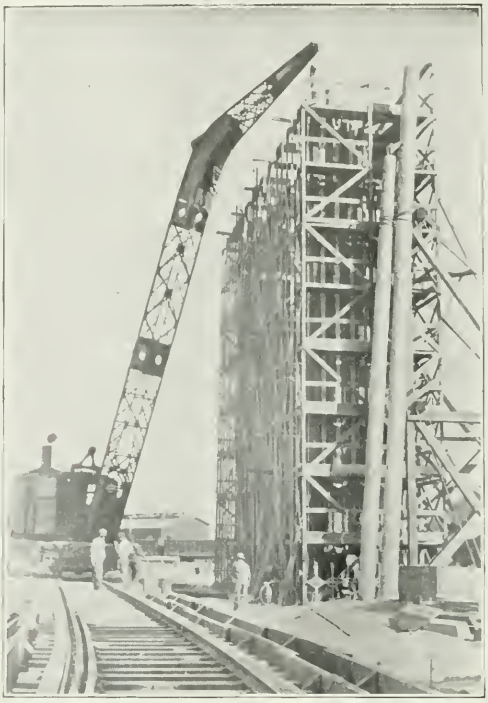

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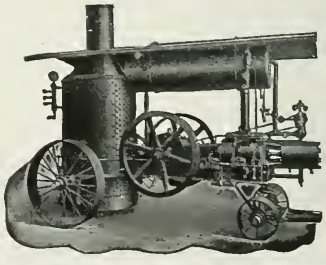

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Compressed Air Magazine

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VOL. XXVI, NO. VII
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JULY, 1921

Modern Development in Manufacture of Building Glass

Compressed Air's Conspicuous Part in the Changes Wrought—Increased Production, Greatly Improved Quality of the Finished Product and a Formerly Arduous Task Performed with Ease and Mechanical Perfection

By ROBERT G. SKERRETT

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THE BIGNESS of America's sheet glass industry may be easier to grasp if we say that in the course of a busy year the active plants are able to produce a matter of substantially 630,000,000 square feet of this material in various thicknesses. To put this in a more concrete form, glass enough of this character is manufactured in a twelvemonth to cover 14,463 acres or an area of quite 22½ square miles!

With these figures before us it is not difficult to visualize the part that so-called building glass plays in our daily life in shutting out wind and rain and letting the beneficent daylight in. America, moreso than any other nation has generously provided for the free admission of sunlight and the withholding of chilling or stormy blasts. Engineering cunning has made this possible; and once more we have a striking example of the adaptability of compressed air to man's diversified services.

America might still be lacking millions of windows or be taxed, as the people are elsewhere, for every healthful, comforting pane but for the inventions of native genius that enable them to manufacture window glass by machine. True, about 40 per cent. of the window glass turned out in the United States is still made by the hand process, as the older method is termed, but it is not unlikely that all of this commodity would be of mechanical fabrication if the apparatus were available for the purpose.

In order that we may comprehend what these machines represent in the way of developments in the art it would, perhaps, be advisable to describe the manual procedure which so long held the field. But, for the sake of those interested in details, first let it be said that the "batch" for window glass is composed of sand, salt cake, and lime, with a small amount of powdered coal or charcoal. In some plants soda ash is substituted for a portion of the salt cake, and this is generally the case where the glass is produced by machine—the latter composition being softer and better suited to the conditions imposed by the mechanical treatment.

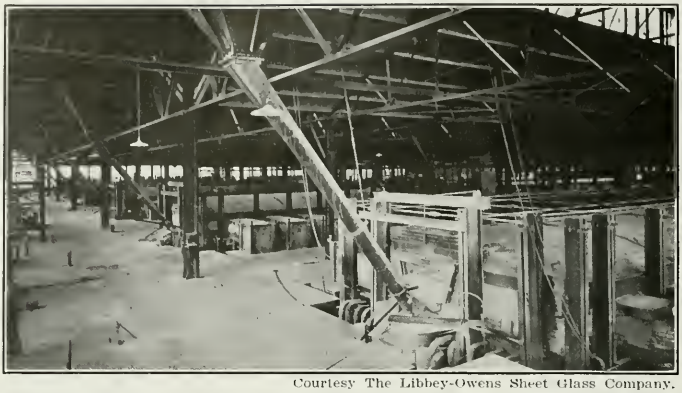
THE INTRODUCTION of the use of compressed air for blowing glass, instead of performing that operation by the human lungs, marked a decided advance in the manufacture of this commodity.

After the introduction of the mechanical blowing of glass by compressed air, a high degree of refinement and standardization was attained on account of the constant volume and pressure maintained during the blowing operation.

In this article, the second of the series, the author gives a detailed description of the various steps in the manufacture of glass for windows, photographic processes, automobile wind shields, church windows, domes, skylights, office partitions and numerous other uses.

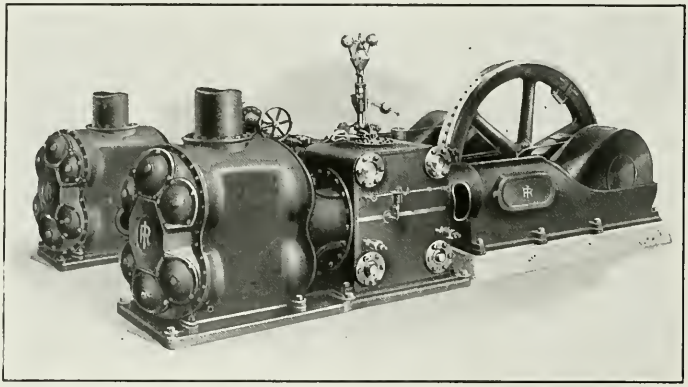
In the hand blowing of glass an associated group or "shop" is made up of three operatives —a gatherer, a blower, and a snapper. Each of these is successively employed in the fashioning of the "rollers" or flasks into which the glass is blown before it is split and flattened into sheets. The *modus operandi* is as follows. The gatherer is equipped with an iron tube about 50 inches long having one end tapered for a mouth piece and the other end flared out to a maximum diameter of three inches. This tool, previously heated, he dips into the molten mass of the tank furnace, and by rotating the pipe accumulates a film of glass on the enlarged head. The worker removes his gather from the furnace, and rolls it upon a block of cast iron in which there is a half-round recess which serves to give the glowing glass a pear-like form. A moment later, he revolves the gather in a blast of cooling air to "set" the mass. Once more he goes to the furnace to add to the quantity of glass on his pipe and then carries it to the cooling "buck" or tub, where the glass is placed on a wet wooden block with a hemispherical cavity —rotating the gather the while. Finally, after five or six trips to the furnace, enough glass is thus built up on the pipe head for the blowing of a cylinder of the desired size and thickness of wall. Now comes the blower's part.

The blower is the most skillful member of the "shop," and acquires his cunning after protracted training. His task is to blow into the highly heated and yielding glass bulb for the purpose of making a long cylinder measuring, when the top and bottom are cut off, from 44 to 62 inches in length and from fourteen to fifteen inches in diameter. The cylinder is modeled by the distending action of the blower's breath and by the elongating pull of the glass itself as he swings the plastic body in a pit at his feet. When the glass cools and stiffens, he takes the growing cylinder back to the furnace, reheats it until it is sufficiently soft, and then blows and swings it once more These operations are continued until the flask has reached the requisite dimensions. The blower's problem is to make sure that his vitreous material is evenly distributed and that his cylinder is straight throughout. According to the thickness of the glass, it is known as single or double strength, and may

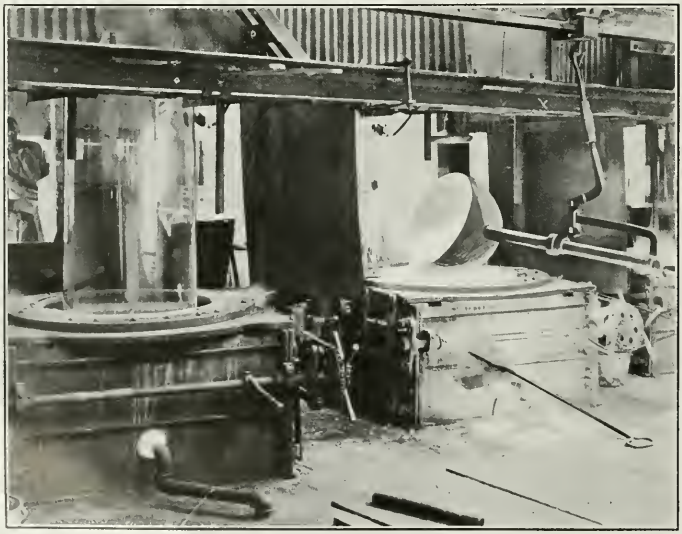


Courtesy The Libbey-Owens Sheet Glass Company.

The charging end of a group of "tanks" in a plant where sheet glass is drawn mechanically. picture shows the chutes by which the batches are continually charged into the furnaces and also gas and compressed air pipes by which the high temperature is maintained on the one hand l the enveloping walls cooled on the other.



ersoll-Rand Class "ORC" Duplex steam driven air compressor for use in glass manufacture.



Courtesy Hires Turner Glass Company.

Ladling the molten glass into a pot preparatory to the mechanical blowing of a cylinder of ndow glass.

be even heavier. A blower will produce nine "rollers" or cylinders of single-strength glass in the course of an hour, and from six to eight of double-strength in the same period.

Before the blower has finished his part of the work he opens out the closed bottom of his great flask. This he does by shoving the lower end of the cylinder into the furnace. When this moderate portion of the cylinder has been duly heated he blows into it with considerable force instantly sealing the mouthpiece of the pipe with his thumb. Next, he exposes more of the flask to the hot gases of the furnace, and this causes the air within the cylinder to expand and to exert a stress that bursts a passage clear through the softened bottom. While the glass is still plastic, the blower swings the cylinder in the pit, and by carefully manipulating it he enlarges the hole to the full diameter of the side walls.

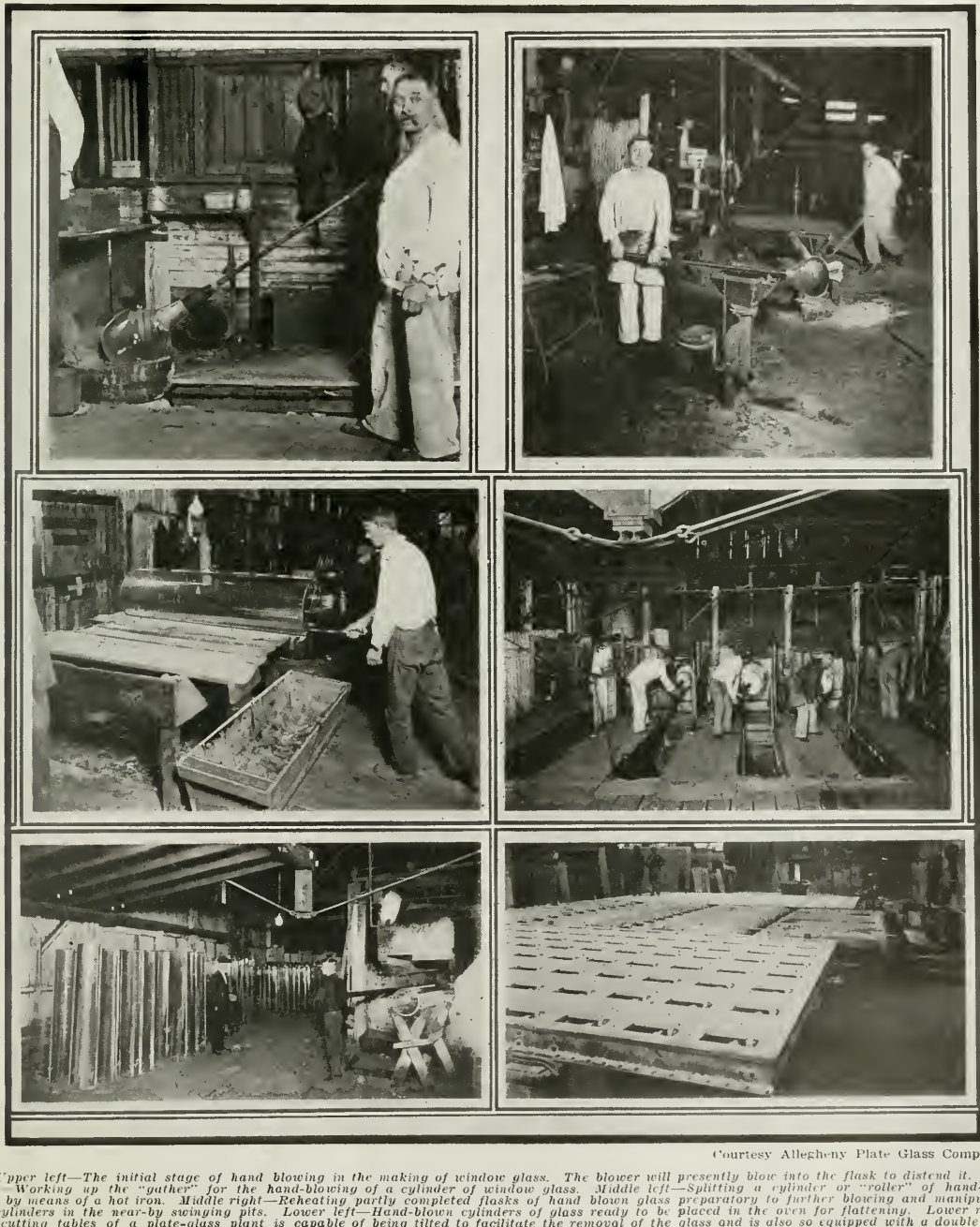
This done, the snapper lifts the cylinder from the swing hole and lays it horizontally in a wooden trough holding a bed of sawdust. With a moist iron, the snapper touches the hot glass at the neck near the flare of the pipe, and a gentle tap suffices to detach the cylinder. Next, he gathers from the furnace a small quantity of molten glass and quickly draws this into a thin thread which he wraps about the cylinder close to the rounded shoulder. This serves to heat a narrow zone, and when a damp or cold iron is applied at that point, the glass splits circumferentially and fairly regularly, thus separating the "cap" from the rest of the body. If the bottom end be ragged or rough, it too, is gotten rid of in the same way. The roller, for so the cylinder is now called, is ready to be split longitudinally. A light scratch, an inch or so long, is the starting medium, and a hot rod, shoved back and forth, from end to end of the roller in line with the scratch, promptly induces a lengthwise crack.

The roller is then wheeled to the flattening oven, where it is placed upon a revolving table carrying a number of slabs or "stones" of fire clay. There it is heated until soft enough to be ironed flat with a long-handled wooden block. The flattener is an expert, and upon the way he does his work largely hinges the subsequent value and usefulness of the window glass.

From the flattening furnace, the hot sheet is swung into the leer for annealing. Single-strength glass takes about half an hour from the time it enters the furnace for flattening until it issues from the far end of the leer. Thence the sheet goes to the cutting department where the operators, with diamonds, cut it into marketable sizes. In a plant of this character compressed air is used for cooling purposes and for regulating the combustion and pressure of the gaseous fuel.

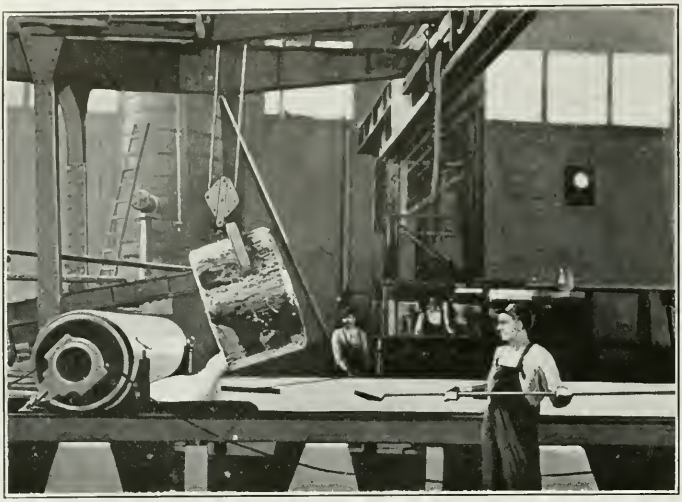
With the foregoing description of hand-blown window glass it will now be easy for us to comprehend and to evaluate the changes introduced by the adoption of mechanical blowing. Efforts to blow window-glass cylinders by machine began in this country in the early "nineties," and it took eight or nine years of costly experimenting to evolve apparatus that gave any reasonable promise of commercial success. Since then, the art has moved

Typical Views Illustrating Some Phases of the Glass Industry of Which the Public Knows Little



Courtesy Allegheny Plate Glass Company.

Upper left—The initial stage of hand blowing in the making of window glass. The blower will presently blow into the flask to distend it. Upper right—Working up the "gather" for the hand-blowing of a cylinder of window glass. Middle left—Splitting a cylinder or "roller" of hand-blown glass by means of a hot iron. Middle right—Reheating partly completed flasks of hand blown glass preparatory to further blowing and manipulating the cylinders in the near-by swinging pits. Lower left—Hand-blown cylinders of glass ready to be placed in the oven for flattening. Lower right—The cutting tables of a plate-glass plant is capable of being tilted to facilitate the removal of the glass and is also so equipped with a double set of rollers that the sheet of glass can be freely shoved from side to side or end to end.



Courtesy Hires Turner Glass Company.

Pouring molten glass from a pot onto the casting table, where the plastic mass will be ironed flat by the big metal roller. One stage in the process of making plate glass.

Courtesy The Libbey-Owens Sheet Glass Company.

The cutting table at the end of the 200-foot leer in a factory devoted to the mechanical drawing of window glass.

The big clay pots in which the ingredients are melted for the making of plate glass. The modeling of these pots is an expensive and tedious operation.

forward with considerable speed; and while the several systems are fundamentally much alike still they differ in certain respects for which their several advocates claim distinctive merit.

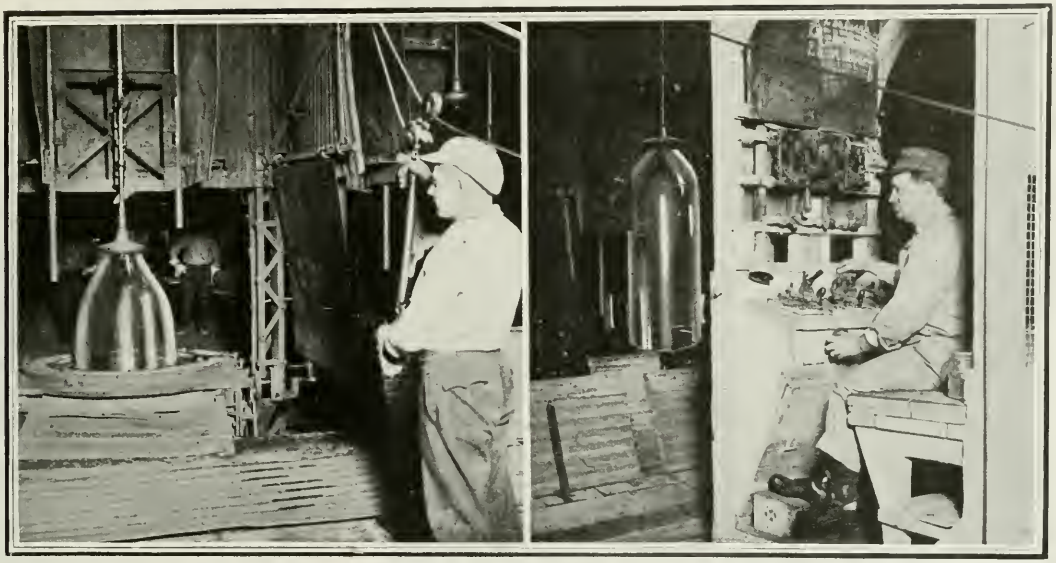
For the lungs of the human worker the inventors have substituted the tireless cylinders of the air compressor, and have thus made certain of an impulsive breath of uniform pressure and flow. The reliability of this operative agency has rendered possible results of unique and worth-while character.

The get-up of a factory of this sort is more complicated and pretentious than that devoted to hand blowing, and while there are relatively fewer employees a greater percentage of these are skilled workers. In a general way, the melting furnace or tank is not dissimilar from that found in a hand plant save that the quantity of glass kept constantly available is apt to be much larger. In some of the machine-blowing factories the glass is ladled from the furnace into pots preparatory to forming the cylinders, while in others the glass flows directly into kilns or basins connected with the furnace, and to that extent reduces the handling of the vitreous fluid. Let us follow the procedure at an establishment of the latter kind.

On three sides of the tank, in groups of four, are arranged the kilns and a corresponding number of blowing machines. Each machine consists of a "cage" or framework which guides vertically an electrically-driven hoist designed to lower and to raise a malleable iron attachment known to the trade as a "bait." The bait is suspended from a bracket and hung so that it can be swung out and forward, when desired. At its upper end, the bait is joined with the compressed air line, and at its lower end it has a bell-shaped terminal with a maximum diameter of about ten inches. The bait is pierced longitudinally by a 1½ in. passage through which the compressed air travels during the formation of a cylinder.

To make a "draw," as it is termed, the bait is lowered into the kiln and brought in contact with a pool of clarified glass confined within the circular hole of a firebrick block or "stone" floating upon the molten bath. This refractory body holds outlying impurities or scum at bay and at the same time helps to shape the cylinder during its genesis and determines its diameter. After the bait has touched the glass and caused some of the latter to cling to it, then the man in the blower booth, which is set in a commanding position, starts the motor that carries the bait steadily upward.

Simultaneously he turns on the air and regulates the supply agreeably to the speed of ascent and the size of the cylinder to be fashioned. In this way, cylinders from 25 to 35 feet long can be formed; and these may range from eighteen to 30 inches in diameter. It is possible to produce a single-strength cylinder in 35 minutes and a double-strength one in about 50 minutes. Manifestly, the speed of the vertical movement is fixed by the rate at which the glass cools and becomes rigid; and it takes a deal of experience before the blower learns



Left—The start of a machine-blown cylinder of window glass. Right—Blower booth or control station in a plant where window glass is blown mechanically.

to control this as well as the flow of compressed air.

When the bait has about reached its upper limit it is needful to cut off the nethermost part of the cylinder. This is accomplished by raising the floating firebrick stone just above the molten glass so that it no longer shields the cylinder at that point from the direct sweep of the near-by gas flames. In a moment or two the bottom of the cylinder is fused away, and the next step is to swing the great tube clear of the kiln and to lower it into a horizontal position upon a movable rack equipped with a series of semi-circular brackets. The cylinder is capped or split free from the bait by an encircling wire electrically heated. In the same way the roller is cut crosswise into three or four sections to facilitate handling, and these, according to their diameter, are divided longitudinally into one or two pieces.

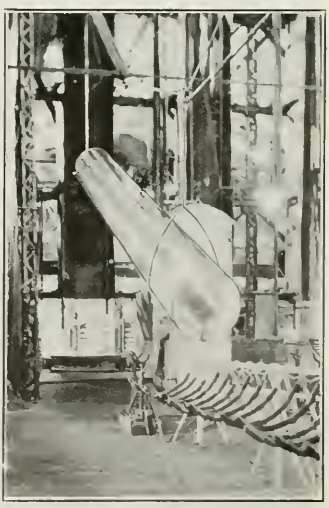
In machine-blown glass of this kind care has to be taken to guard against the formation of local aggregations of foreign bodies which, by reason of their weight, might sag and cause a cylinder to rupture and, possibly, to collapse through the tearing action of escaping air. The "skimmer," therefore, with suitably hooked rods, can reach the defect anywhere around the tube and push the lump slightly inward, cooling the glass the while, thus arresting any movement of the objectionable mass and preventing a puncture. The skimmer must do this protective work when the imperfection is only a few inches above the surface of the molten glass in the kiln.

In a plant equipped with twelve kilns, the blower in charge of the control station can attend to a "bank" or group of four machines, and in the course of a day three banks can produce 288 rollers, i. e., from 5,000 to 6,000 boxes of window glass.

A variation of the machine-blowing method just described consists in drawing the cylinders from a series of specially made fire-clay pots which are set beneath the bait-hoisting cages. These pots are virtually duplex containers inasmuch as the bottom or dividing partition is placed midway in the depth of the vessel. Each pot has two projecting lugs at opposite sides, and these support it and allow the container to be turned upon its horizontal axis for the purpose of bringing each chamber successively into service. A large iron ladle, hung at one end of a balanced bar fifteen feet long, and suspended from an overhead runway, is shoved into the tank and filled with molten glass, the charge weighing from 500 to 600 pounds.

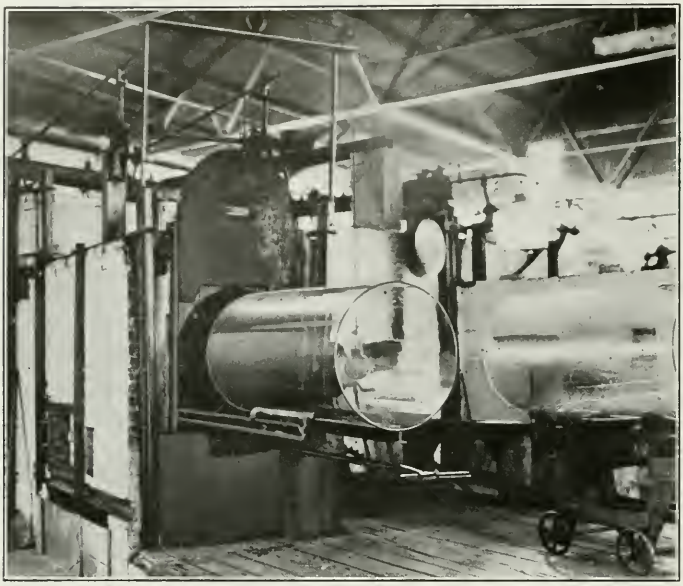
This glass is then conveyed to a waiting hot pot and poured into the upturned chamber of that vessel. With this done, the operator in the blower booth lowers the bait, and when the latter has touched the glass he reverses the motion of the electric hoist and simultaneously opens the throttle in the compressed air line. The pot holds only enough glass to produce one cylinder so that further upbuilding ceases automatically the moment the supply is substantially exhausted. The long transparent tube is then ready to be swung clear of the cage for splitting, etc. At the same time the pot is tipped to dump out any unused glass, and this brings the other bowl into position for filling.

Cylinders can be drawn measuring 466 inches after both of the ends have been cut off, and these rollers range in diameter from twenty inches to 30 inches. In passing, let it be said that the pots used in this process generally require a ripening period of four months after they are made, and their service life may be anywhere from one hour to two weeks. By the machine method it is feasible to obtain glass of a greater variety of thicknesses and to realize better results at a lower price than is practicable where the cylinders are hand blown. Much glass 3/16-in. thick is manufactured in this way, and this material is widely utilized for automobile wind shields and in the glazing of large windows where previously only plate glass was deemed fit. Further, photographic glass can be drawn by the same apparatus. Before the war this material and picture glass were imported exclusively. Indeed, America is thus enabled to secure at home better photographic and pic-



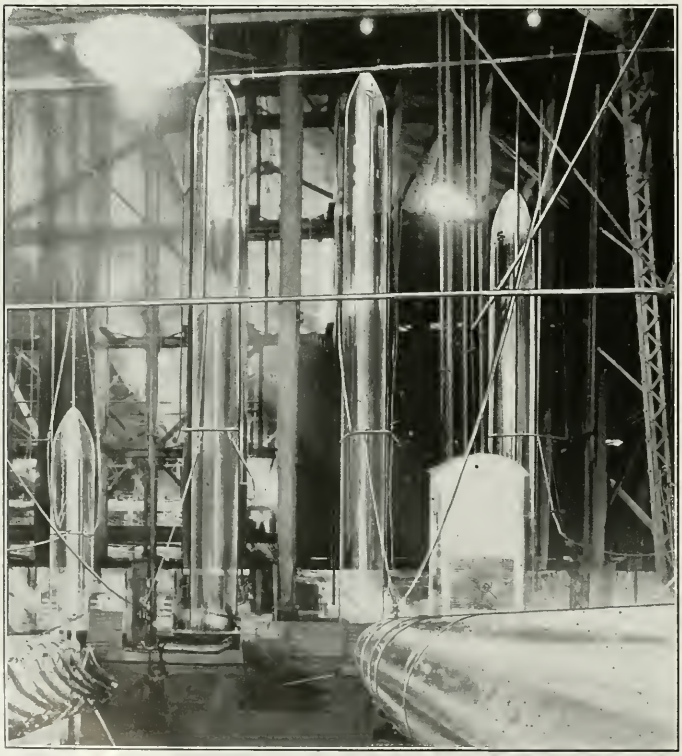
Courtesy Hires Turner Glass Company.

A newly blown cylinder of window glass being lowered into a rack where it will be cut circumferentially into a number of sections.



Courtesy Hires Turner Glass Company.

Split sections of a machine-blown cylinder of glass being run into the flattening oven.



Courtesy Hires Turner Glass Company.

The floor of a factory devoted to the making of window glass, showing the simultaneous blowing by compressed air of four great cylinders in different stages of completion.

ture glass than was hitherto shipped from Belgium.

The distinctive characteristic of photographic glass, for instance, is its thinness and evenness. It is necessary that the glass be such that it can be flattened without superficial defects; and a great deal depends upon the straightness of the blown cylinder. A cylinder that is not straight will be wrinkled when flattened out into a sheet, and while these waves may be well-nigh imperceptable still they would be objectionable to the dry-plate manufacturer. The sensitive emulsion would lie unevenly, and the plate would not respond uniformly to the action of the light reaching it through the camera's lens.

When the machine-blown cylinders have been cut circumferentially into a number of rollers, each about five feet long, and when these have been "shawled" or split lengthwise, they are passed on to the flattening oven, which is pretty much like that installed in a hand-blown plant. These sheets then journey through the leer, and when removed from that annealing furnace they are quite commonly dipped in a bath of water and muriatic acid. The plates are handled at this stage by a compressed air hoist. The glass is now ready, when dry, to go on to the cutting room. In this system of glass production the breakage loss amounts to from ten to fifteen per cent. This waste is called "cullet," and the broken glass is carried right back and fed proportionately, with the raw ingredients, into the admission end of the melting tank. A big tank will hold as much as 130 tons of molten material. This is not hard to understand, for such a structure of refractory bricks or blocks may have inside dimensions giving it a length of 138 feet, a width of 32 feet, and a depth of five feet.

Natural or producer gas is the fuel used in these regenerative furnaces, and compressors are required to raise the gas to the desired operative pressure. This may be done either by compressing the gas, itself, or by mixing the combustible with a nicely regulated flow of compressed air. The melting heat is around 2600 degrees Fahrenheit. The glass solidifies when the temperature drops below 1600; and it is therefore essential that the material be nearly white hot and fluid when it is ladled out for transfer to the pots at the blowing machines.

A notable departure in the manufacture of window glass was the perfecting a few years ago of mechanical facilities for the drawing directly from the furnace of great sheets of that commodity. To-day, there are apparatus in service that draw continuously from the pool of molten glass sheets five feet wide and fully 200 feet long. To start operations, a bar of iron is lowered into the bath where the movement of the glass toward the bait is promoted by knurled fire-clay rolls. Next, the bar is lifted electrically two or three feet, pulling with it a pendant film of the vitreous substance, and then this bait, with the plastic glass trailing along, glides over a horizontal roller. In this manner, the glass reaches the adjacent flattening table, which is a traveling metal belt, where longtitudinal tension suffices

to flatten the glass while it is passing from the plastic to the rigid state.

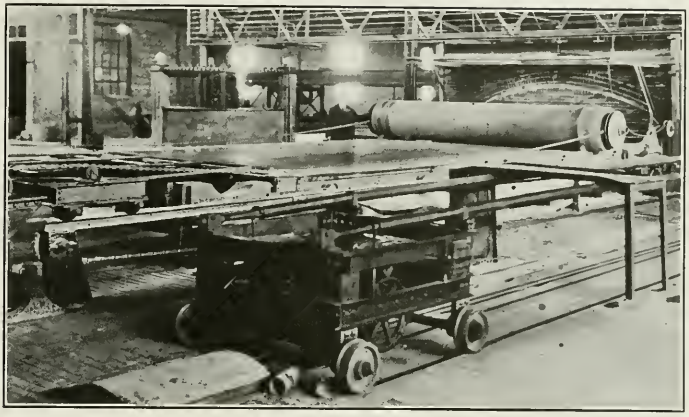
Just after the forward end of the growing sheet leaves the flattening table, the bait bar is snapped off and removed, as its duty of initiating the formation of a sheet has been finished. From that point on, the glass is gripped at its outer edges by clamp bars and carried onward through the leer, for a run of 200 feet, by a series of power-driven rollers spaced every twelve inches. At the exit of the annealing furnace the sheet issues upon a cutting table where it is lopped off into units five feet wide and 208 inches long. These are later cut up into various commercial sizes.

Once a sheet is begun by hoisting the bait from the molten bath, the ingeniously arranged action of the knurled fire-clay rolls tends to sweep the fluid glass, as it were, from four sides toward a common center and thus to stimulate its upward travel as part of the ever-lenghtening viscous film. Anyone that has made taffy can picture something of the phenomena at work in this case. During a portion of its short vertical journey, the sheet is protected from the direct blast and heat of the tank, and this causes the material to stiffen somewhat; but in a few seconds it is exposed to a series of gas jets which soften it sufficiently to permit its bending at right angles over the bending roll as it advances onto the flattening table. Once more we see how nicely regulated temperatures figure vitally in the successful handling of the product.

The "strength" of the glass is regulated by the speed of drawing. A sheet 1/24-in. thick comes over the bending roll at the rate of 100 inches a minute, and quarter-inch glass can be produced at a rate of 24 inches a minute. This mechanical process, logically, dispenses with the flattening furnace and the hand work of the highly-paid flattener; and it is said that an interval of only 40 minutes elapses between the birth of a single-strength sheet in the tank and its arrival at the far end of the leer. One of these machines will turn out 700 boxes of window glass in the course of 24 hours.

Before concluding the story of window-glass making it is worth while citing that our hand and machine plants in this department of the industry manufactured in 1914 more than 8,000,000 boxes, each containing 50 square feet. In 1916 the output exceeded 10,000,000 boxes, and their total value was approximately $20,000,000.

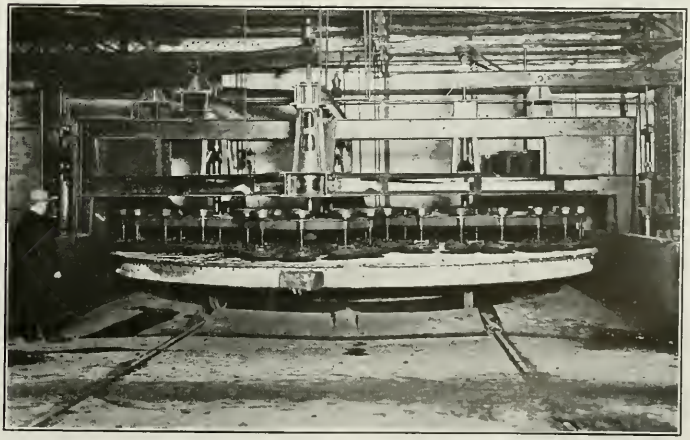
The production of plate glass in the United State has grown apace in latter years, and in 1917 the thirteen active plants provided 75,000,000 square feet of this material. We use glass of this sort for mirrors, show cases, wind shields, windows, wainscoating in buildings, and for various other purposes, such as deck lights, air ports, etc. The price varies according to the thickness of the glass and the size of the sheet, and the market value has mounted considerably since 1914, when the output of 60,383,516 square feet was estimated to be worth $14,773,787. In this branch of the industry engineering has wrought a veritable revolution in numerous directions. The improvements have all been designed to speed up manufacture, to reduce labor charges, and



A comprehensive view of the casting table and associate equipment in a plate-glass plant.

Courtesy Allegheny Plate Glass Company.

The melting furnace in a plate-glass plant with batches in push carts ready to be dumped into hot pots.



Courtesy Allegheny Plate Glass Company.

An up-to-date polishing table in the plant of one of the newest plate-glass factories.

to insure a finer and more uniform commodity. Indeed, it is authoritatively asserted that our plate-glass factories can furnish an article equal and in many cases superior to the best made abroad.

The materials used in the plate-glass batch are white or silica sand of a select grade, limestone, soda ash, salt cake, arsenic, and carbon. These ingredients are melted in large fire-clay pots having an outside diameter of about 52 inches and a height of something like 33 inches. The modeling of these pots alone is a special craft, and the utmost care is needed in the preparation of the clay and the subsequent drying and ripening of the vessels. Under stress, and with considerable risk, pots may be used for a melt after they are only two months old, but the most approved practice calls for a drying period of half a year. A pot will last anywhere from 27 to 75 melts, and the average service life is about four weeks. Each pot of the size described will hold enough glass to produce a sheet of 300 square feet, half an inch thick. Before a pot is ready to be charged it has to be preheated in a furnace for five days. Then it is filled and shifted into the melting furnace, and there it takes seventeen hours to render the batch fluid.

When the pot of glass is ready for teeming it is conveyed by an overhead crane to the casting table, which has been previously cleaned by compressed air—the latter being directed by ten-foot lengths of piping which can reach every part of the table. The table top is of cast iron beautifully machined to insure a uniform surface and, of course, is level. On the two long sides of the table are metal strips or battens of a height agreeably to the thickness of the sheet of glass to be formed, and upon these is drawn mechanically a large, heavy roller which flattens out the glass while plastic. The length of the sheet is regulated by an adjustable batten which can be moved longitudinally upon the table.

As soon as the molten glass is poured upon the table, the roller is started; and it is a matter of only a few moments ere the glowing mass is ironed out and molded into a radiant sheet. Before it has had time to lose more of its heat, the now rigid plate is shoved by an electrical apparatus into the first compartment of the multi-chambered leer, where its temperature is brought up to that needful for the primary stage of annealing. A succession of automatically-functioned lifting rails, rollers, and pushers transport the sheet from one division of the leer to the other—the heat dropping gradually until the plate is not too hot to handle when reaching the point of exit. There, the door is elevated pneumatically and the sheet forced out upon a series of horizontal power-driven rollers which are brought close to receive the sheet and then to convey it to either of two flanking cutting tables.

Through openings in the top of the cutting table castors, set at right angles to one another, can be alternately raised above the table plane for the purpose of lifting the sheet and of facilitating its translation back and forth or to right and left.

When the edges of the plate have been squared by the cutters, who use diamonds for the purpose, the supporting table is tilted at a sharp angle by a hydraulic mechanism and the sheet is then removed by an overhead crane which carries it away and stacks it upright against a convenient rack. To effect this transportation, the glass is caught at its uppermost edge by an ingenious grip designed so that it pinches harder the heavier the burden. At this state in the manufacture the two surfaces of the glass are rough and the stuff is translucent but not transparent, and it is twice as thick as it will be when polished and made ready for the market. Single sheets of this plate glass are thus produced having dimensions of 160 inches by 240 inches.

The finishing department is composed broadly of two groups of machines—one for grinding down the rough surface to a certain degree of smoothness, and the other for giving the well-known polish which renders the glass transparent. In a general way the grinding and polishing apparatus are alike, differing only in the character of the mediums which rub the glass and in the materials employed to effect the two operations. On round cast-iron tables, about 26 feet in diameter, are laid, in a suitable cement, a number of plates of the unfinished glass, and in order to protect the outer edges of these sheets from sweeping blows smaller plates, similarly secured to the table, are used to fill in the remaining spaces.

The tables are mounted on car wheels and are run upon tracks which extend from the grinding to the polishing machines. When a table is prepared, it is rolled under the grinding machine and caught by a "spider" or circular frame. This wheel-like structure is revolved horizontally—the speed increasing as the work progresses; and the energy required may range from ten to fifteen horse-power. The grinding is done by a number of runner bars which are brought in contact with every part of the glass's upturned surface. The treatment is begun with coarse sand which is gradually substituted by finer grades. The sand is followed by emery of diminishing abrasive qualities. It takes something like an hour and a half to wear away the glass to an acceptable state of smoothness. With this attained the table is released from the spider and wheeled over to and under the polisher, where it is engaged by another spider, likewise power driven.

The polishing outfit consists of four revolving frames from which are pendant numerous pivoted pads or discs which can rotate freely as their carriers turn and the table sweeps around beneath them. All told, there are 70-odd of these mechanical rubbers, and not an inch of the surface of the glass escapes their finishing touch. Rouge and water obliterate all scratches; and after an hour and a quarter of vigorous application the sheets can be taken off and their nether surfaces put through a corresponding course of grinding and polishing. In this fashion a rough plate one-half an inch thick becomes a beautiful marketable article of only a quarter inch through.

And now for the concluding angle of the subject of building glass, that having to do with those varieties known as obscured, wire, and opalescent glass. The extent of this department of the industry can be gauged when we learn that there are 25 factories engaged in the business and that seven years ago this country produced 54,728,023 square feet of these commodities, which were valued at $4,008,187. Obscured, wire, and opalescent glass are really forms of plate glass, and the last of these is the consequence of certain ingredients which give it its characteristic cloudy or milky appearance. Opalescent glass is in demand for church windows, sky lights, domes, and in the glazing of passenger coaches, etc.; and one American enterprise has made this suggestive statement anent this material: "Through the use of a thorough process of color blending and properly cooled casting plates, we are producing a machine-made article which in some respects, may be considered superior to similar hand-made products." Obscured glass is clear glass having usually an impressed figure on one side and a smooth or polished surface on the other. The decorated or modeled surface is due to the action of an engraved cylinder which is rolled over the plastic sheet while it is on the casting table. Glass of this sort is used extensively in transoms, door panels, office partitions, etc.

Wire glass is somewhat more complex in its get-up. It may be obscured, as just described, on one side or it may be smooth on both sides, but it always carries imbedded in its mass a network of polished steel wire. There are two ways of placing the wire in the glass. By one process it is rolled in between two sheets that are produced well-nigh simultaneously, and by the other procedure the metal mesh is forced into a single but thicker plate while the glass is still hot and yielding enough to permit this. If any of the surfaces of obscured, wire, or opalescent glass are to be polished the sheets are dealt with as in the case of plate glass. Since 1914, our manufacturers have not only amplified their establishments in this branch of the industry but they have, besides, added to their skill and to their ability to turn out much improved commodities. From now on, these plants will be able to satisfy many of our requirements and to play a big part in our foreign trade.

In every one of our variously occupied building-glass factories, the indispensable compressor is a feature of the mechanical equipment, and in ways too numerous to mention compressed air renders helpful service. From the melting furnace on through all of the subsequent manipulations of the glass compressed air stands forth as the handy medium par excellence. Besides contributing to a larger and better output it does much to promote the bodily wellbeing of the workers—an industrial desideratum of the first order.

The total production of electric power by public utility companies in 1919 was thirty-nine billion kilowatt-hours, according to the United States Geological Survey. Of this power 62 per cent was produced by fuels—35,000,000 tons of coal, 11,000,000,000 barrels of oil, and 21.7 billion cubic feet of gas—the remainder by water power.

Pneumatic Caisson Foundations for Tall Buildings

Highly Developed Use of Compressed Air for Building Deep and Difficult Footings Impossible to Construct by any Other Method

By FRANK W. SKINNER*

UP TO THE days of the present generation, foundations for all tall and heavy buildings, no matter how massive, delicate, or costly, were necessarily of one of three types, namely, surface foundations, foundations constructed in open pits, or foundations supported on piles driven if possible, to hard strata.

When the loads to be carried are light, and when there is no reason to provide against local disturbances, the foundations of buildings on ordinary soil may be simple beds of concrete, brick, or stone masonry just below the level of cellar excavation.

If the foundation pits penetrated through quicksand the bottom frequently rose faster than it could be removed, adjacent structures were liable to be undermined, great damage occasioned, and the limits of depth were often quickly reached. Below water level, work was liable to be slow and hazardous and could generally be carried on only for a limited distance.

Many costly and beautiful buildings erected in former days have settled so badly as to be seriously injured, and sometimes destroyed. In the alluvial soil of New Orleans and the soft clay of Chicago, settlements of one or two feet or even more, have occurred that generally did great damage. Recognizing this fact architects and engineers deliberately planned to allow for considerable settlement and exercised all their care to proportion loads and design buildings so that settlement should be uniform throughout, a precaution which was often successful in avoiding structural injury.

In many cases the difficulty of constructing reliable foundations under unfavorable conditions prevented the location of buildings on sites that were otherwise desirable, and tall and heavy buildings or those containing delicate machinery were built only where the building was good.

New York Conditions Promoted Caisson Development

In the financial district at the southern end of Manhattan Island, New York, where the soil is exceedingly unfavorable for the support of tall buildings, congestion has been so great, and business interests so enormous, that rental and property values had become very high 40 years ago, and has since been steadily increasing, so that building sites on them are the most expensive in the world and require the construction of very heavy tall buildings that justify extraordinary pains and expense in their foundation.

Up to the advent of modern passenger elevators and steel cage construction, buildings here had an average height of only four or five stories and an extreme maximum of not more than ten or twelve, developing loads for which provisions could be made by ordinary methods sufficient for the soil requirements.

THE ART of carrying massive foundations through treacherous quicksand, flinty hardpan, subterranean rivers, ancient buried timbers, and otherwise impenetrable rocks and boulders, to support on solid rock deep below the surface, has been perfected within the last 30 years.

Concrete superstructures are thus built in the dry and their foundations are carefully inspected, tested, and adjusted far below water level.

The same process is used for constructing huge subterranean dams, enclosing multistoried cellars, and protecting them from tremendous earth and water pressures.

General view of the Woolworth Building, 972 feet 7 inches high above the footings of the 61 pneumatic caissons carried through quicksand to a maximum depth of 121 feet to support the 250,000-ton structure which is the tallest in the world.

The soil consisted of artificial fill, sedimentary deposits, earth, and vegetable mould to below ground water level which corresponds approximately with tide level. The next strata is sand, some of it clayey, with pockets of gravel and occasional boulders, reaching down to hardpan or solid rock from 50 to 200 feet below the surface.

There are several subterranean streams occupying the beds of ancient creeks and ponds, and the sand varies from coarse to exceedingly fine, the latter often becoming quicksand when disturbed or under adverse conditions. Some of the quicksand is exceedingly lively so that it will boil up furiously in the bottom of the excavation, will flow long distances on a very flat slope underground, thus displacing superimposed soil, undermining buildings and causing settlements near the excavation. It may also squirt almost like a water jet, through orifices as small as a nail hole, becoming very fluid when penetrated, although dense and hard when thoroughly drained and confined laterally.

As the top soil would only sustain pressures of 1,000 to 3,000 pounds per square foot, it was necessary to correspondingly limit the loads on shallow foundations thus restricting the height and weight of buildings that could be erected on them.

If the foundations were carried deep enough to reach an undisturbed sand strata not liable to settlement by future operations adjacent to it, the cost of excavation below water level was apt to be very great and the results uncertain at best.

Important foundations here were at first generally built on wide masonry footings or on timber grillages supported by piles, the latter in some cases becoming decayed on account of the recession of the ground water after the building was constructed and causing great danger and damage.

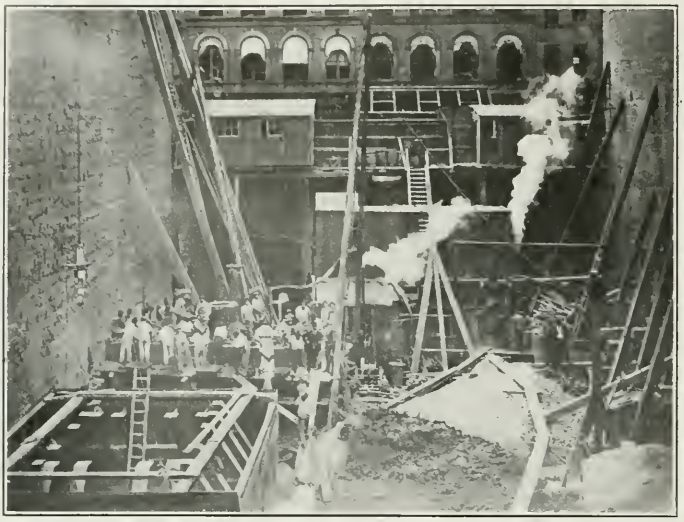
Wide shallow foundations at approximate cellar floor level were built with grillages of single, double or treble tiers of I-beams embedded in concrete to distribute the concentrated column loads. These often nearly or quite covered the entire area of the lot, and sufficed for buildings up to fifteen or eighteen stories in height.

Column Foundation Caissons

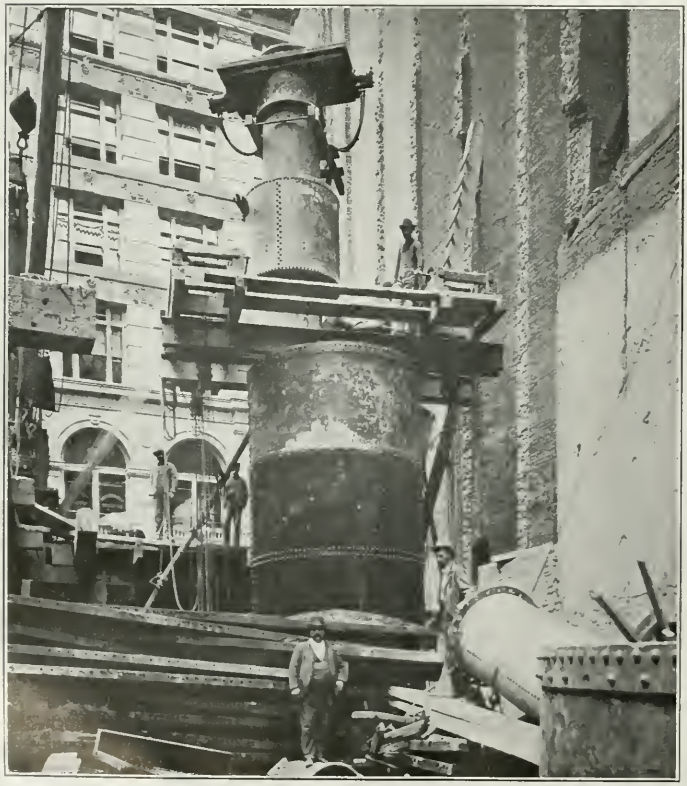
As the construction and equipment of steel buildings were perfected and the upper stories became popular for office use, the height and weight of the buildings increased enormously and tremendous concentrated loads were carried to the foundations which required areas greater in some cases than the entire surface of the lot.

Under these conditions a method was developed of carrying almost unlimited loads to

*Consulting Engineer, Associate Editor, Public Works.



Erecting in the cellar excavation for the Manhattan Building, Broadway, the working chamber of first pneumatic caisson used for a building foundation.



Airlock with pneumatically operated sliding doors installed on air shaft in the Commercial Cable Building, one of the first to have pneumatic caisson foundations.

solid rock at maximum depths of 150 feet below the pavement, by means of the pneumatic caisson process using compressed air to exclude quicksand and water from the open bottoms of permanent caissons sunk vertically to the solid rock by interior excavation.

The caissons are essentially bottomless, airtight boxes of suitable dimensions and great strength that are sunk vertically, bearing usually on rock or hardpan, filled solid with concrete, and serve as permanent footings on which are built solid pier shafts reaching to the bottom of the general excavation.

In design and method of installation the caissons closely resemble and have been developed from pneumatic caissons used for subaqueous and subterranean foundations of bridge piers and other engineering structures described by the author in the COMPRESSED AIR MAGAZINE, March, 1921.

For extremely heavy loads independent caissons are usually provided for the separate columns, but for lighter loads or when the columns are grouped closely together, two or more columns may be supported from the same caisson, which is then likely to be long and narrow. For ordinary loads caissons are from five to twelve feet in diameter for single columns and for several columns may have sides from five to 40 feet long. Usually from ten to 100 caissons are required for the foundation of a modern office building. They are sunk through sand, mud, clay, quicksand, boulders, gravel and hardpan and through the decayed rock surface, in groups of from two to ten simultaneously, and at a speed of from one foot to 50 feet in 24 hours. The sinking is often retarded in New York City, by encountering buried logs, ancient timbers, old foundations, sunken ships, cribs, rip-rap and other obstacles which sometimes have to be dynamited.

Pneumatic caissons are generally more expensive than any other kind of foundations, but they are also positive and reliable and can be made as strong and immovable as the rock itself. The cost varies with the number of caissons, their depth, and local conditions and always involves a heavy fixed charge for the installation and removal of the air compressors, engines, derricks and other equipment. On small jobs it may be as much, even in normal times, as $50 per cubic yard of excavated material.

The First Building Caissons

Pneumatic caissons were first used for the construction of foundations for buildings, in the case of the Manhattan Life Insurance Building on lower Broadway, which was built about 30 years ago, Kimball and Thompson, architects and Charles O. Brown, engineer. The eighteen-story framework, 240 feet high from curb to parapet, has steel and cast iron columns with loads of up to 200 tons each, supported on fifteen cylindrical and rectangular steel caissons that were adopted because the weight of the building was greater than the allowable load on the maximum number of piles that could have been driven in the lot area, even if spaced only 30 inches apart.

The Commercial Cable Building, New York, has the exterior walls and columns supported

on twenty rectangular steel caissons and the interior columns on eighteen cylindrical steel caissons, all of which were sunk to rock about 60 feet below the curb. The walls of the caissons were extended above the roofs of the working chambers by permanent steel cofferdams.

As the caissons sunk and the frictional resistance to their progress increased, additional weight to force them down was provided by filling the cofferdams with water, and by the use of tackles attached to the tops of the cofferdams and to platforms placed on the surface of the ground and heavily loaded with cast iron.

The 55 steel caissons for the foundation of the Mutual Life Building, New York, were similar to those in the Commercial Cable Building except that the rectangular wall caissons eight feet wide and from fifteen to 22 feet long were provided at each end with pairs of vertical 6 x 4-inch angles, the exterior flanges of which registered with each other forming guides to keep the caissons aligned together while they were sunk through 30 feet of clay and sand, and eight to fifteen feet of hardpan and then through an underlying strata of quicksand from five to 30 feet thick, to solid rock from 70 to 90 feet below the curb and from 50 to 70 feet below the ground water level.

Rectangular Wooden Caissons

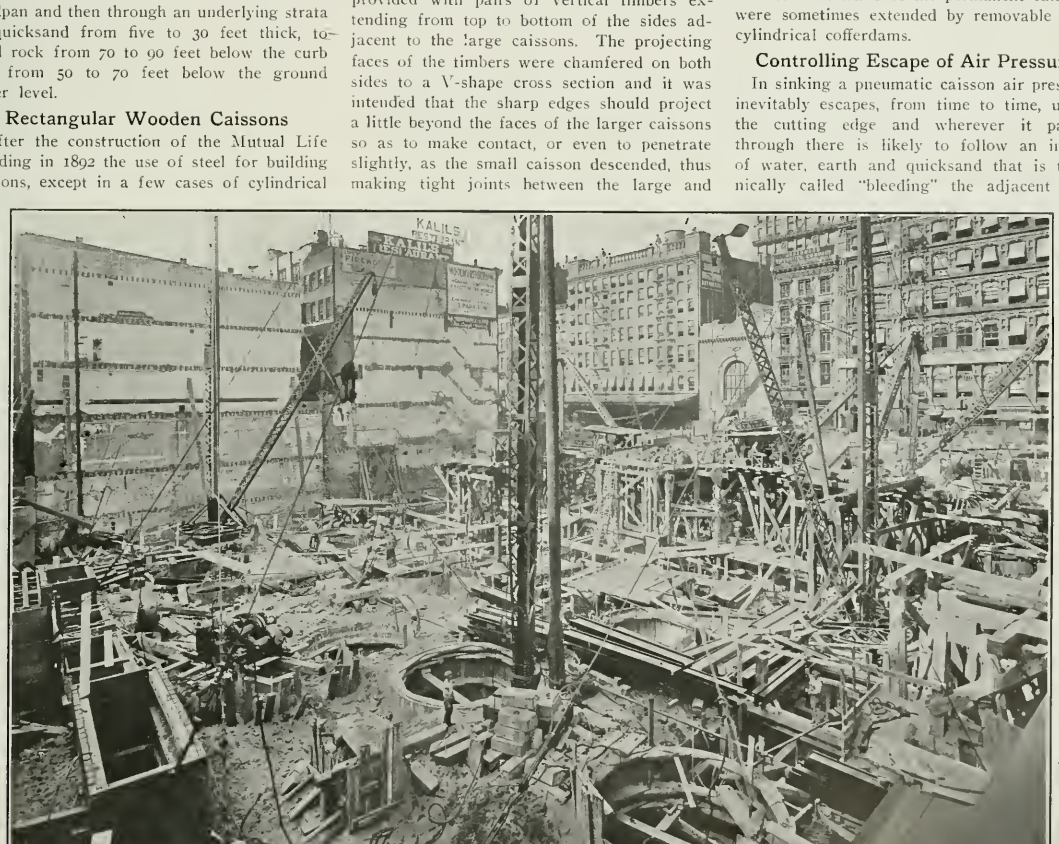
After the construction of the Mutual Life Building in 1892 the use of steel for building caissons, except in a few cases of cylindrical caissons of small diameter, was generally superseded by wood, a fair example of which was afforded by the 25 story bank of the State of New York, which was built in 1902 with 37 rectangular wooden caissons made with a framework of horizontal 6 x 8-inch timbers covered with vertical 3-inch sheathing planks, and carrying a roof of two solid courses of 8 x 8-inch timbers. These caissons were surmounted with permanent wooden cofferdams of similar construction made in two courses, each ten to eighteen feet high. The cutting edges were made of riveted steel plates and angles and the caissons were sunk through quicksand about 42 feet to a stratum of hardpan and the excavation was continued through it to solid rock at a depth of four feet below the cutting edge where it was extended two feet wider to give a greater bearing surface for the concrete filling.

The caissons were sunk with a clearance of about four feet between, and in order to unite these caissons and form a continuous substructure, auxiliary caissons were subsequently sunk in between them. These caissons were provided with pairs of vertical timbers extending from top to bottom of the sides adjacent to the large caissons. The projecting faces of the timbers were chamfered on both sides to a V-shape cross section and it was intended that the sharp edges should project a little beyond the faces of the larger caissons so as to make contact, or even to penetrate slightly, as the small caisson descended, thus making tight joints between the large and small caissons. This was successfully accomplished in some instances and in others difficulty was encountered and so much water penetrated that divers were required to stop the leaks.

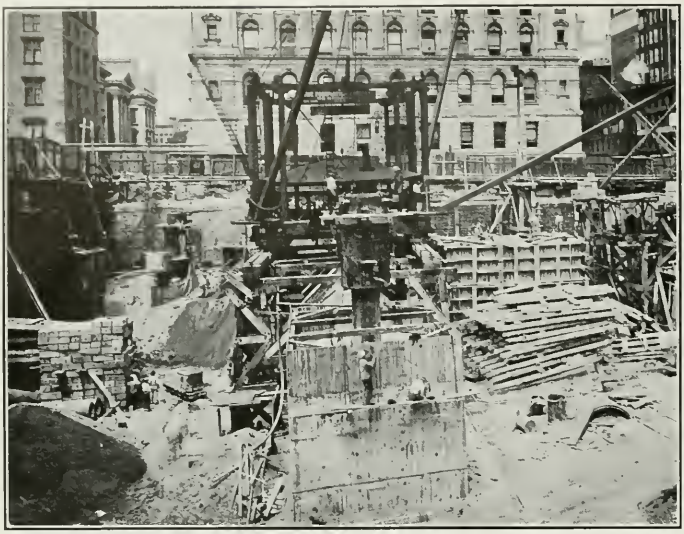
For caissons carrying a single concentrated load, especially those for interior columns, a circular cross-section is preferable because it gives the minimum exterior surface and frictional resistance for a given volume, and because it offers arch resistance to exterior pressure and does not need internal bracing for moderate dimensions. Cylindrical caissons were first made of thin, riveted steel plates; later, in order to reduce the delay and cost of construction, wood was substituted and they were built with vertical staves three or four inches thick, planed on all sides, and with the radial edges cut to the exact required angle. They were usually made in sections twelve to 32 feet long and screwed to interior steel angle rings. The roof of the working chamber was formed by a domed steel plate firmly attached to the staves and provided with an opening to which the air-shaft was flange connected. The walls of the permanent caissons were sometimes extended by removable steel cylindrical cofferdams.

Controlling Escape of Air Pressure

In sinking a pneumatic caisson air pressure inevitably escapes, from time to time, under the cutting edge and wherever it passes through there is likely to follow an inflow of water, earth and quicksand that is technically called "bleeding" the adjacent soil



Constructing pneumatic caisson foundations for the Woolworth Building. The upper ends of the circular and rectangular cofferdams project above the bottom of the general excavation, which was subsequently carried to a much greater depth after the caisson work was completed.



Sinking rectangular wooden caissons through sand to permanent bearings on bed rock for foundations of Municipal Building. Cast iron derrick blocks shown at right and left. Piles of steel and wooden form panels in foreground.

nd may cause dangerous settlement of nearby tructures. In order to reduce the possibility f undermining adjacent foundations on sand, bove the level of the cutting edge, John F. 'Rourke devised the simple expedient of aking the cutting edge inclined instead of orizontal by bevelling the bottom of the caisn and putting the lower edge next to the djacent building, thus compelling the air to scape at the farthest point from the building. ircular wooden caissons were used for many ew York buildings, including the Fabbri esidence.

Elimination of Separate Roofs

At first the roofs of all types of pneumatic aissons were made with heavy beams and irders to carry the weight of the pier above iem. Later the roof was practically eliminatd in many cases by making the pier itself erve as a roof. It rationally followed that ie caisson walls themselves were made of oncrete integral with the roof and with the ier the whole being eventually built in one r more sections according to local conditions.

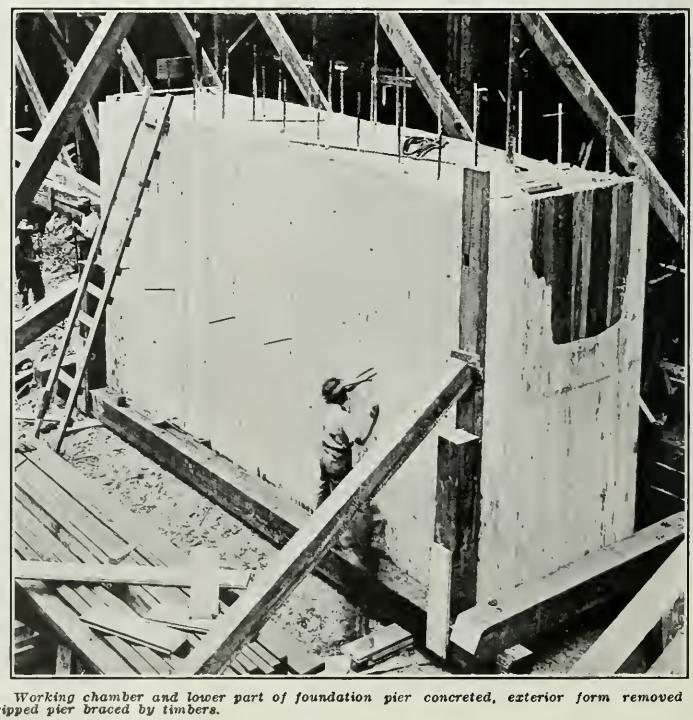
Although caissons having wooden walls surounted with steel or concrete roofs are still ometimes used under special conditions, the eneral practice is now to construct the entire orking chamber of reinforced concrete surounted by a mass concrete pier built in one r more sections around the air-shaft which is ade collapsible and removed after the caisn is sunk to bearing. The inner faces of the aisson walls are generally offset in rectangar courses so as to be thick at the top of the orking chamber and thin at the cutting edge.

The piers are usually completed to the full eight, or to half or more of the height acording to circumstances and available head oom, before the sinking of the caisson is comnenced. The caissons and cofferdams thus resent the appearance of tall, slender piers that gradually disappear below the surface after the excavation is commenced in the working chamber. The instability due to their narrow bases and great height is counteracted by bracing on all sides with inclined struts or rakers, the lower ends of which often engage pile footings or dead men, while the upper ends are attached to timber yokes enclosing the forms that may be greased to reduce the friction when the caisson decends. Some contractors have covered the exterior surface of the sheeting of wooden caissons and cofferdams with heavy grease to facilitate their sinking and reduce the skin friction that has been computed to amount to as much as 600 pounds per square foot.

Construction Facilities

As the combined area of the caissons often amount to from 30 to 80 per cent. of the total area of the lot, and as they are distributed over the whole surface with comparatively small spaces between them, there is inadequate space and clearance left for the installation of the contractor's bulky plant and equipment, storage of material and for working room. In congested districts where very little street space can be obstructed and heavy traffic must not be interrupted, contractors generally cover the whole or a large portion of the cellar excavation with a heavy timber working platform at street level, and utilize the additional space thus secured for loading, unloading, storage, office and shop room, and sometimes for the installation of light equipment.

Heavy machines like air compressors and boilers are generally installed in the bottom of the excavation or in the sidewalk vaults outside the lot area, but it sometimes happens, as in the case of the Woolworth building, that it is impossible to permanently locate all of the heavy machinery and it is therefore necessary to temporarily place it in one position un-



Working chamber and lower part of foundation pier concreted, exterior form removed and stripped pier braced by timbers.

til after a number of caissons are sunk, and then to transfer the plant to supports on the completed caissons where it can remain until the substructure is finished.

In New York City the cellar excavation is generally carried down to ground water level, the sides are retained by sheet piling where necessary, the street level platform built on piles or trestle-bents, and the plant installed by one or more stationary mast and boom derricks commanding all parts of the work. Booms are usually from 40 to 70 feet long and have a capacity of ten to fifteen tons. They are, however, sometimes replaced by shorter booms attached to the vertical posts of traveling towers, that move back and forth across the lot on the working platform.

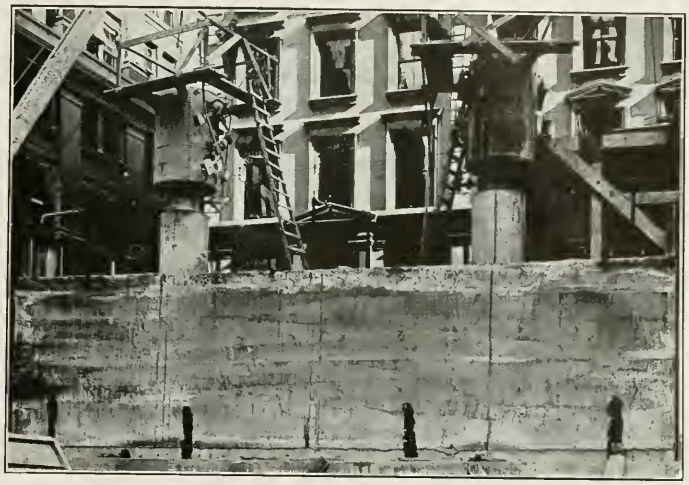
Subterranean Walls

The sidewalk is generally supported on a temporary bridge and is also protected by a horizontal double roof carried on timber bents and having capacity to support a load of about 600 pounds per square foot, thus making it available for a very convenient working platform on which the contractors', engineers', and architects' offices are often established. One or more elevated hopper-bottom storage bins of five to ten yards capacity are installed in the street or on the working platform where trucks can drive under them, receive a load of spoil and carry it away without materially obstructing the traffic. They also provide reservoirs to retain the excavated spoil and permit excavations to be carried on without interruption by slight delays in the trucking. The centers of the caissons are carefully located and holes are cut through the working platform to clear the sides of the caissons and cofferdams or forms which are handled by the derrick and project through the working floor until the caissons are sunk below it, after which the floor is restored.

As all of the tall office buildings have steam plants, pumping water distribution and sewage systems, ventilating apparatus, elevator mechanism, light and power dynamos and various other mechanical appliances in the lower stories where also there is provision made for coal supplies and storage and frequently for bank and safety deposit vaults and other rentable space, it is often profitable to provide a maximum amount of space below the level of the street so that in New York, two, three, or even four stories are frequently built below the curb carrying the cellar floor far below ground water level and the lower portions of their exterior walls are likely to be built in quicksand.

New York Stock Exchange

The first example of the continuity of concrete construction in the adjacent sections of the wall caissons was afforded by the New York Stock Exchange, where three sides of the lot were enclosed by what amounted to a subterranean dam eight feet thick and 50 feet high, built in sections 24 to 30 feet long with pneumatic caissons having vertical wooden walls and detachable domed steel roofs over the working chambers. The caissons were placed end-to-end from twelve to fifteen inches apart, with their outer faces on the lot lines, forming three sides of a rectangle,



Forepart of pier showing additional courses of concrete built on top of the working chambe and all these sunk by exterior excavations carried on through two airlocks and shafts. The pie enclosed by timber yokes braced by inclined struts with bearings on the surface of the concrete, a indicated by the vertical black patches.

Ten-ton wooden pneumatic caisson swung to position for the Singer Building.

the fourth side of which consisted of a building with its foundations previously carried down to hardpan.

After the very successful construction of the Stock Exchange foundations, the principle of connecting long and narrow wall caissons to form a submerged dam has been adopted for a number of tall buildings, and various modifications have been made of the details of the concrete joints bonding adjacent caissons together. In the case of the 25-story building for the Trust Co. of America, the wall caissons sunk through 45 feet of quicksand to a penetration of three feet in hardpan, 80 feet below the curb, were connected by wells excavated between them and concreted under air pressure retained by an air lock installed at the top of the well and permitting the men to excavate below it.

Caisson Bracing

These wall caissons and cofferdams, from six to eight feet thick filled solid with high-class concrete, possess great shearing and bending strength, and projecting considerably below the cellar floor, often penetrating hardpan, offer high resistance to horizontal pressure. As the excavation inside the wall is carried down below the tops of the caissons the unbalanced pressure from the quicksand and water produces enormous shearing and flexure stresses in the caissons which tend to act as cantilevers anchored in the hardpan at the base.

Eventually the inner faces of the caissons are braced across the whole width of the lot by the thick concrete cellar floor and by the steel beams, girders, and concrete slabs in the several basement floors which are designed to have special bearings against the walls and resist their displacement. This resistance cannot however be utilized until after the substructure and part of the superstructure are completed. Therefore, in some cases the caissons have been temporarily provided with systems of temporary transverse, horizontal braces extending across the length and width of the lot and put in place in successive tiers from the top down as the cellar excavation proceeds. The braces generally consist of single or double twelve by twelve-inch timbers from ten to twenty feet apart horizontally and from six to ten feet apart vertically, supported at intersections by vertical shores. They are removed after the steel columns and girders are in position, and the latter have been wedged to bear against the caissons.

Woolworth Building

The $12,000,000, 55-story, 152 by 136-foot Woolworth Building is 760 feet six inches high above the curb and 982 feet seven inches high above the bottom of the foundations. The estimated weight of the building and contents is about 250,000 tons and is supported upon 61 pneumatic caissons and concrete piers with foundations on solid rock, at a maximum depth of 12[illegible] feet below the curb.

The circular caissons from six to nine feet in diameter were concreted in steel forms and the rectangular ones of similar dimensions were concreted in wooden forms, all of them being built to the height of 25 feet at the first operation, extended to 50 feet before sinking was commenced and the concreting finally completed at a third operation after they had been sunk about 50 feet. As many as nine caissons were simultaneously under air pressure, which reached the maximum of 45 pounds per square inch. Work was carried on continuously by a force of about 125 sand hogs.

Working chamber of cylindrical pneumatic caisson with wooden staves for Fabbri residence. Cutting edge and inside horizontal forms made with circular angle iron rings. A section of domed steel roof shown inside working chamber.

The air was supplied by three Ingersoll-Rand compressors having a combined capacity of 6,000 cubic feet of free air per minute compressed to 50 pounds, delivered at a temperature of about 150 degrees and cooled artificially to 65 degrees before it was supplied to the caissons. Pressure was regulated by a receiver of 500 cubic feet capacity and by the use of an automatic reducing valve at each caisson.

The caissons were sunk through coarse sand, fine sand, water and quicksand and through a six to eight-foot stratum of hard granite boulders, to the irregular surface of the rock about 120 feet below the curb, which was dressed horizontal to receive the concrete with which the caissons were filled under full pneumatic pressure.

One of the caissons six and one-half feet in diameter was sunk to a depth of 130 feet below the curb in twenty consecutive hours.

Municipal Building

The 40-story New York Municipal Building, 580 feet high, has maximum column loads of 4,575,000 pounds, and is supported on 107 pneumatic caisson foundations sunk from 77 to 150 feet below the curb and involving some of the most difficult, interesting, and important caisson work ever executed for building foundations.

Among the latest examples of pneumatic caisson construction are those for the foundations of the Cunard Office Building, Broadway, and the Stock Exchange Building extension, Wall Street, the latter at this writing being completed by the Underpinning and Foundation Co., which has executed much difficult foundation work in New York and elsewhere. The Stock Exchange Building lot was enclosed by the caisson foundations of an existing building on one side and by continuous new wall caissons bonded together on the other three sides and sunk through wet sand and about ten feet of hardpan to rock, 65 feet below the curb. Before sinking the caissons were concreted to the full height in three courses, and after sinking, the caissons which contained approximately 2,300 yards of concrete, were connected by concrete put in position under air pressure.

Extended Footings

An interesting development of pneumatic caisson work was perfected by John F. O'Rourke in the foundations of the Emigrant Industrial Savings Bank Building which included 30 rectangular wooden caissons from five by five to thirteen by sixteen feet. The walls were made with 6 by 60-inch horizontal timbers, faced on the outside by two-inch vertical planks extending twenty feet above the tops of the working chambers to form permanent cofferdams. The caissons were sunk in about sixteen to twenty hours each to bearing on hard, compact gravel at a depth of about 64 feet below the curb.

The concrete piers are loaded about eight tons per square foot and in order to reduce the load on the gravel to four tons per square foot the bottoms of the caissons were flared out about two feet on each side. This was accomplished, under air pressure, by cutting out, from the top down, sections of the side walls and excavating through the sand and gravel under protection of poling boards driven at an angle of 45 degrees. Special poling boards were arranged at the corners of the caissons and the bottom areas were thus increased to double the size of the piers and filled solid with concrete placed under the air pressure, thus reducing the total cost of construction below what would have been required to make the caissons the full size of the enlarged footings.

The design of pneumatic caissons for building has been improved and standardized, their construction has been highly developed and the cost reduced by a few engineering contractors of large experience who have specialized in this work for many years, and have maintained well trained organizations and abundant equipment. They have also developed many ingenious improvements in methods, plant and operations.

A large proportion of the pneumatic caissons in New York have been built by John F. O'Rourke or by the Foundation Co., most of the remainder having been built by the Underpinning and Foundation Co., Halbrook, Cabot & Rollins, and by Arthur McMullen. Compressed air is generally supplied to the working chambers by standard compressors, most of them of the straight line type and reliable for continual service, day and night, for weeks and months at a time, when an interruption to the air supply at critical times might cause loss of life and would be almost sure to involve great property damage.

A mining shaft in Sombrerete, Mexico, is almost exactly on the Tropic of Cancer, and at noon on June 21 the sun shines to the bottom, lighting up the well to a vertical depth of 1100 feet or more.

Lubricating Compressor Cylinders and Bearings

By H. MOONEY*

SOME USE of compressed air and consequently the need for air compressors is found in almost every industry. The distribution is world wide and is so finely divided that it is rather difficult to find a plant which does not have at least one air compressor.

The fact that the work done on air, in compressing it, produces heat has led many operators into the error of thinking that a heavy bodied, high flash oil is required. In reality the flash point is not a factor and the body should be chosen to meet the lubricating and piston sealing requirements. An air compressor is simply an air pump. Air generally at atmospheric pressure and temperature, is drawn into a cylinder and is then compressed and pushed out by the moving piston at a higher pressure.

The heating of the air through compression takes place gradually. Not until near the end of the stroke does the temperature rise much above 250 degrees Fahrenheit in two-stage 100 pound units. In some exceptional cases we do encounter a discharge temperature above 300 degrees Fahrenheit, even up to 400 degrees or 500 degrees, but such operating conditions are not at all common in single stage 100-pound units.

The oil for the internal lubrication of air compressors should be applied, by means of mechanically operated force feed lubricators, directly to the intake valves and cylinder walls.

The use of sight feed drop oilers is not as good because the feeds cannot be closely regulated, a necessity which is provided for with the mechanical force feed lubricators.

Oil for external lubrication may be applied to the bearings by any of the standard methods, but an automatic reliable delivery is of course preferred.

Use only a small feed of oil to furnish lubrication. It is neither burnt, vaporized nor washed away, therefore, a small quantity of the correct oil will maintain the necessary oil film whose prime function is to assure a piston seal.

The use of different brands of oil for different types of air compressors or for different pressures is neither necessary nor advisable. The range of temperatures, pressures and operating conditions throughout the entire field of air compressor work is well within the limits which define the most efficient range of service values for a heavy medium bodied mineral oil.

Use only the best quality of lubricating oil. With the correct high grade oil in service the presence of any deposit on the valves can mean only one of two things—either too much oil is being fed or the intake air is dirty.

Many operators believe that the flash point is indicative of the vaporizing temperatures of the oil, and that excess oil is removed from the cylinders by evaporation. This is not true. The flash point is the lowest temperature to which the oil must be heated to give off vapors in sufficient quantity to produce an explosive mixture with air. The amount actually evaporated, while taking the flash, amounts to only a small fraction of one per cent.

Petroleum oils do not have fixed boiling points since they are complex mixtures of hydrocarbons of different boiling points. Alcohol is a definite chemical compound and has a definite boiling point which is 173 degrees Fahrenheit. Water is a definite chemical compound and has a definite boiling point of 212 degrees Fahrenheit. A mixture of alcohol and water would be a mixture of two compounds having different boiling points and when heated would start to boil at 173 degrees Fahrenheit, but the final portion would boil off at 212 degrees Fahrenheit. Similarly, petroleum oils which are complex mixtures do not have definite boiling points, but as in the case of the alcohol and water mixture, have a "boiling point range."

Now let us compare the relation between the flash point and the actual boiling point of oils. A light spindle of oil which has a viscosity of 60 seconds at 100 degrees Fahrenheit flashes at 310 degrees Fahrenheit. A distillation run on this oil gave the first drop off the condenser at 605 degrees Fahrenheit and at 650 degrees Fahrenheit only twenty per cent. had distilled off.

Even if the temperature of the compressed air were high, the oil being in contact with the cooler cylinder wall would never run over 300 degrees Fahrenheit. Since the first drop of a light spindle oil comes over at 605 degrees Fahrenheit it can be readily seen that it would be impossible for a heavy medium bodied oil which has a higher flash point than the spindle oil to distill off at 300 degrees Fahrenheit.

Evaporated oil is a gas just as steam (evaporated water) is a gas. It is at the discharge valves that we find the heaviest oil deposits, and the greatest carbonization. Steam would not condense on baffles placed in a superheater, neither would evaporated oil condense on the hottest obstruction; namely, the discharge valve. It follows that the oil found on these valves must have been carried there in a liquid form.

The fact that we do not have a high enough temperature to evaporate more than a small fraction of one per cent. of the oil and that the liquid oil deposits are found at a point where condensation of oil vapors will be impossible, proves quite conclusively that excess oil is not removed from the cylinder by evaporation and that the flash point of the oil is not a real factor.

The only way that the oil could be carried out of the cylinder would be in the form of an oil spray. This is what actually happens. The excess oil is sprayed by the moving piston, atomized and carried out by the high velocity of discharging air. All obstructions in the path of the air act as baffles to which the oil drops adhere. It naturally follows that the rate of its atomization is dependent on the amount of oil feed, subjected to the influence of the piston speed and the current of discharged air.

It is a well known fact that often all three cylinders of Diesel engine compressors can be perfectly lubricated by applying oil to the low pressure cylinder only. The excess oil from that cylinder is carried by the air in the form of a spray which deposits in each successive cylinder sufficient oil to lubricate it. This separation of the oil from air will occur even when the air increases in temperature in the later stages of compression. If the oil were evaporated, as a gas, it would go through the higher pressure cylinders with the air without helping their lubrication. As there is little moisture to contend with and moderate cylinder wall temperatures, the necessity for maintaining the oil film will be satisfied with a very small oil supply.

It is important that only enough oil should be introduced to maintain the lubricating film necessary to prevent wear on cylinder walls and to form the piston seal necessary to maintain compression. The exact amount is difficult to determine except by trial, as the area of the cylinder wall surfaces, the piston speed, the temperature of the cooling water and the efficiency of the water jacket are variables in different sizes and types of compressors. We believe that compressors are rarely, if ever, operated with a small enough oil feed. The tendency is always to over lubricate. Operating troubles are never due to too low a rate of oil feed.

We frequently have called to our attention the presence of impurities, such as sand, dust, soot, ashes, etc. These are usually combined with the excess oil in the form of deposits which enter the cylinder as impurities in the intake air. Every precaution must be taken to prevent impurities from getting into the cylinder for they always form into a paste with the excess oil, to interfere with lubrication.

Laboratory tests can not determine the suitability of air compressor oils; the process of its manufacture is more important and actual service records are the best guide. All petroleum oils when heated and subjected to the hot compressed air of an air compressor will decompose more or less, forming mainly carbon and oxidized oil. Some oils decompose more readily than others. It is, therefore, essential that an air compressor oil must be of such nature that it will decompose very little while on the cylinder walls.

A straight mineral oil of heavy medium body will maintain the necessary lubricating film and seal under severe conditions. This is the heaviest bodied oil which will give satisfactory operating results. A heavier oil will

*Mgr. Eng. Builders Dept. Vacuum Oil Co.

cause unnecessary oil drag, increasing the frictional losses and will have a greater tendency to collect dust and dirt in the form of deposits. This oil should have the highest flash consistent with its body and should be specially treated to resist decomposition by oxidation in the presence of heated air and filtered to remove all impurities.

Reliability of Lubrication

A close adherence to the following rules for installing and operating air compressors will climinate the possibility of troubles.

The end of suction or intake pipe should be located outside the engine-room in clean surroundings. Air should be cleaned through a suitable screen or strainer, which will keep out impurities. The cooler the air the more efficient the air compressor. Cooling water for cylinder jackets and heads must always be turned on before the air compressor is started. Frequent temperature readings should be made of the cooling water at inlet and outlet; this will indicate any irregularity in the action of the discharge valves.

Discharge air temperatures should be regularly recorded, as any rise in temperature will be an indication of irregularity of operation—i. e., deficient cooling, carbonized discharge valves or a poor piston seal.

Drain cocks should be placed at low points in coolers, in discharge air line, and in receivers, for the drawing off of the accumulated oil, water and impurities. Draining should be attended to at regular intervals, frequent enough to insure cleanliness of the system. A check on the feeding of excess oil through its accumulation in the receiving tank is easily determined.

Reliable pressure gauges should be installed on receivers and should be checked with standard gauges at regular intervals, corrections being made when necessary.

Soap and water should be used for cleaning the internal parts of compressors. The soapy solution should be fed to the valves and cylinder in the place of compressor oil for two or three hours. All surfaces should then be wiped clean and oiled with compressor oil to prevent rusting. We recommend cleaning at frequent intervals. Where compressors are operating in dusty locations they should be cleaned at least once a month—even more frequently is still better and valves should be inspected for cleanliness weekly.

According to a recent report from Consul Hale of Plymouth, a syndicate has been formed for the purpose of developing the extensive beds of lignite located in the Bovey Basin, near Newton Abbot, Devon, England. This deposit of lignite is estimated to consist of millions of tons. It is stated that before the war the beds were worked by a group of scientific Germans, who were chiefly interested in obtaining the oil. The present scheme embraces both the manufacturing of oil from the lignite and the utilization of the by-product gas for purposes of electricity.

China has a permanent air-mail service between Pekin and Tien-Tsin.

100-TON WRECKING DERRICK EQUIPPED WITH COMPRESSOR

By C. W. GEIGER

THE 100-TON derrick barge recently constructed by the Crowley Launch & Tugboat Company of San Francisco is equipped with a 390 foot air compressor for working drills and other tools, and for supplying air to pontoons, or for forcing water out of wrecked hulls.

This is said to be the largest derrick barge of its kind on the Pacific Coast. The craft is as staunch, sound and complete a piece of cargo handling and salvage apparatus as any that floats on waters adjacent to the Pacific Coast. The barge was designed by Leland S. Rosener of the Crowley Company and equipped at the Crowley Shipyard at Oakland, Calif.

The barge itself is 125 feet in length, 50 feet wide and eleven feet deep. A triangular girder frame of steel 85 feet in height towers above the wooden hull. The boom is a lattice girder of steel 100 feet long and is designed to take 100 tons at a 50-foot radius and an eighteen-ton weight on its maximum working radius. The lines for the eighteen-ton hoist, for the 100-ton hoist and for luffing the boom, are all carried from blocks at the top of the boom to blocks at the top of the stiff frame, and from thence down to sheaves on the lower cross members of the frame, thence to the winches in the deckhouse under the frame.

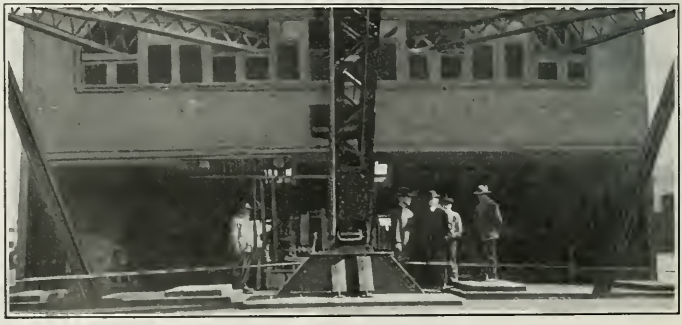
Steam for the main hoisting engine, air compressor, wrecking pumps, electric lighting plant is furnished by an oil-burning Scotch Marine boiler carrying steam at 160 pounds; 200 barrels of fuel oil and 400 barrels of fresh water are carried in special steel tanks located in the hold. Living accommodations are provided for a large crew of men and the fuel and water supplies are sufficient to enable the barge to remain outside on a wrecking job for several weeks at a time.

One of the chief uses to which the barge will be put will be to move stranded vessels. It will also be used in handling heavy pieces of cargo, installing boilers and heavy equipment in new vessels and in wrecking work. Equipped with a powerful compound winch, terrific pulling force can be utilized, and when properly anchored off a wreck this pull will be sufficient to drag from the beach, a large steamer. Soon after the derrick barge was placed in commission, it pulled the steel tanker *Vacuum* from the mud, after a fleet of tug boats had failed. The *Vacuum* stuck in the mud when a chain broke at the launching of the vessel in the Moore Shipyards, Oakland.

General view of derrick barge at San Francisco water front.

PORTABLE AIR COMPRESSORS IN COAL MINES

The replacement of compressed air piping by electric wires has made it difficult in many mines to employ compressed air for use to which it is much better suited than electricity, says *Coal Age*. In consequence the introduction of portable air compressors has been rapid. Electricity cannot be used in the mining of highly gaseous coal and in such cases portable compressors make possible the operation of ordinary and post punchers. Compressed air is preferable for drilling in hard rock and well adapted for drilling in softer material. Cement-gun work demands the use of air under pressure, and by the use of it electrical workers can rapidly drill holes in the hardest of mine roofs for the reception of trolley-wire hangers. Such portable compressors are useful for the operation of riveters and paint sprays and might be profitably employed for the dislodgment of coal dust from the tops of timbers and the ribs of haulageways. With a portable compressor near the point of application there is little fall in pressure and much economy in operation, but care should be taken that the compressor is not overloaded.



Showing equipment on derrick barge.

Compressed Air Improves the Electric Motor

ACCORDING to the popular conception, there is no relationship between compressed air and electricity; and yet the electric motor at its best is what it is in some vital respects because of the beneficial services rendered by the compressor.

There was a time, and that not long ago, when the electric motor was reasonably looked upon as a decidedly delicate apparatus that required well-nigh continual supervision and nursing while in operation to keep it fit for the task assigned it. No one then associated ruggedness with these motive mechanisms, and it was commonly supposed that they could not be installed in any place where they could not be kept under the watchful eye of a qualified electrician. But this state of affairs has been radically changed because of the march of the art and the skill and engineering cunning devoted to the manufacture of these motors.

To-day, the electric motor functions under conditions that would have been deemed prohibitive or speedily destructive a while back; and it is probably not an exaggeration to say that these drivers are commonly more self sufficient, durable, and dependable than many other types of prime movers that are fundamentally sturdier and less exacting in their structural getup. It is no unusual thing now to find electric motors tucked in out-of-the-way places where it is not easy to reach them, and where the only attention they get is a finger of grease for lubrication every two or three months. Worse than that, they are called upon to run week in and week out in the presence of a damp, dusty, or possibly a really dirty atmosphere, and this in direct violation of the essentially delicate electrical phenomena involved in the successful working of the apparatus.

Notwithstanding the basic needs of the motor, and the conflicting circumstances of an unfavorable environment, still electric motors are entering fields of usefulness where, theoretically they should be utterly unsuited. They are indispensable to the propelling of submarines when those boats are submerged, and they meet requirements despite the drip, drip of the condensing moisture-laden air; they perform endless tasks on other battle craft and contend the while with temperature and atmospheric variations of a trying nature; they do their bit aboard merchant shipping and stand up to the rigorous exactions of that department of commercial activity; they actuate looms, etc., in silk mills and such, where troublesome dust or fuzz from the filaments and fabrics is ever present; they draw cars in mines where subterranean springs and seepage keep most things wet; they operate machine tools and are exposed frequently to the splash of oil and scattering bits of metal; and they open and close the maws of grab buckets used in handling raw materials of sorts calculated to clog if not to damage mechanisms of a robust character. In short, the motor is, at first blush, a paradox, for it fits in and functions where, "according to the book," it should not. And that it does so is because of the protective defense which is perfected through the agency of the air compressor.

Without going into the technical niceties of the electric motor—be it of the direct or the alternating current type, most of us know that there are some magnetic phenomena involved, and that coils of cotton-covered copper wires or bars are required to induce certain of these indispensable effects. The wires or bars are insulated by the textile coat, one from another, and upon the degree of this insulation depends the proper working of the entire apparatus. If the cloaking fabric were torn or worn away, thus baring neighboring metallic surfaces; if oil or water should injure the cotton or saturate it so as to promote a short circuit, then inevitably the machine would be put out of service and possibly much time and labor would be needed to make the apparatus fit again.

It is with insulated wires or bars that the electrical manufacturer forms the coils for the field and the armature circuits of his motors—in a sense, these elements are parts of the very vitals of his apparatus. He must, therefore, make sure of their complete insulation and do all that he can to safegurad that factor against the varied conditions of employment. And now for the story of how this is achieved in one thoroughly up-to-date plant where electric motors of a superior make are produced; and, incidentally, we shall see just how pneumatic facilities contribute to this end.

In the make up-of field coils, etc., the windings are composed of many turns of wire, gradually forming a compact mass, and around each strand of this wire is a double covering of cotton holding a goodly percentage of air enmeshed in its texture. And the oxygen, so imprisoned, is a potential source of trouble should it be allowed to combine with oil or moisture and thus lead to corrosive or rotting action. The confined air in the textile must be got rid of lest it interfere with the complete saturation of the cotton when an impregnating material, in a fluid state, is applied. The substance in question consists of an asphaltic base combined with other suitable ingredients; and when heated to the desired degree the mixture flows freely.

The impregnating outfit, at the establishment in question, is composed of two steam-jacketed cast steel cylindrical tanks, each four feet in diameter and eight feet long, with their major axes vertical. They are linked beneath the floor and near the bottom by a pipe, in which is set a suitable by-pass valve, which permits the hot liquid to flow alternately from one to the other, agreeably to the stage of the impregnating operation. As the accompanying illustrations show, the cover of the dipping tank is lifted off and a group of taped coils are then lowered into the receptacle.

Next, the cover is put in place and seated

Courtesy Electro Dynamic Company.

Trucking a lot of armature coils into an oven for baking.

Courtesy Electro Dynamic Company.

An operative in the winding room taping armature coils preliminary to their impregnation.

tight by means of heavy hinged bolts and nuts. When everything is secure then a vacuum pump is started, and as it withdraws the air from the dipping tank the suction extracts, at the same time, the air held within the cotton covering and between the convolutions of wire. Simultaneously, the tank is heated by the enveloping steam jacket until the internal temperature is about 250 degrees Fahrenheit, the heat serving both to dry the textile and to facilitate the evacuation of the air. The vacuum is gradually increased to 25 inches, and is maintained for an interval ranging from three to six hours agreeably to the size of the coil and the mass of wire and cotton to be dealt with.

With this stage of the procedure finished, the by-pass valve is opened and the asphaltic mixture is then fed from the neighboring tank until it rises and submerges the dried, air-exhausted coils. With this effected, the by-pass is closed and air pressure is applied to the fluid—the pressure mounting up to 60 or 80 pounds to the square inch.

Under this impulse, the impregnating substance is driven into the cotton, completely saturating it and filling up every interstice, driving out the while any lurking bubble of air. Again, depending upon the size and number of coils to be treated, the pressure is held from one and one-half to three hours. At the end of that time, the by-pass is opened, the ebony fluid is forced back into its near-by receptacle and then, with the pressure in the dipping tank reduced to that of the atmosphere, the lid is unbolted and the coils are taken out.

In handling the tank lids, and in raising and lowering the coils, a pneumatic hoist is employed. Apart from ease of control, this type of hoist is installed in the name of safety. The asphaltic substance on the treated coils, a quantity of which is exposed in some open tanks in the impregnating room, is somewhat inflammable, and it is important that the risk of fire, through an electrical short circuit or any other cause, shall be reduced to a minimum. Therefore, compressed air is requisitioned as a harmless and effective motive medium to actuate the hoist. The equipment is capable of dealing with loads up to 4,000 pounds.

Courtesy Electro Dynamic Company.

Sealing the cover of the dipping tank preliminary to starting the vacuum pump. Dead lights in the top of the cover permit the workmen to look into the tank and to see that the coils are completely submerged when the asphaltic material is admitted.

Courtesy Electro Dynamic Company.

A batch of field coils being lowered into the dipping tank for impregnation. The workman at the right has his hand on the wheel which turns the stem of the by-pass valve controlling the movement of the asphaltic fluid from one tank to the other.

After their removal from the pressure dipping-tank, the coils are hung up and allowed to drip for an hour or two, during which time the asphaltic material hardens, and the wires, textile, and the coating become one solid mass in the case of each coil. The impregnation serves the double purpose of improving the insulation and of safeguarding the windings against moisture, dust, and the intrusion of abrasive dirt, etc. Similarly, oxidizing air is held at bay.

Mainly by reason of this defense the coils for fields and armatures acquire a ruggedness and a capacity to stand up and to function well under trying conditions of diversified sorts. It would be next to impossible to realize the same security if the impregnation were the result of mere soaking. The secret of success lies in the alternating application of suction and pressure.

When the coils have finished the dripping period, following their withdrawal from the impregnating tank, their electrical leads are attached and the coils are given another wrapping of tape. Once more they are submerged, but this time in an oil-proof varnish and in an open tank. When they have dripped long enough, the coils are shoved into chambers or ovens where they are baked for six hours in a temperature of 230 degrees Fahrenheit. When this coating has set, the coils are given an additional taping, a third dipping, and a final baking of six more hours.

Now, even the non-technical can grasp why motors, when their field and armature coils have been shielded in this thorough way, enjoy an immunity against numerous service menaces which enable them to go on working when other machines, less carefully fashioned, would give trouble and possibly come to a halt.

WATER POWER WITH HEAD OF OVER A MILE

What is probably the highest-head hydro-electric plant in the world is installed at Fully, Switzerland, operating at a net head of 1,650 m. (5,412 feet). The installation is near Martigny, in the Rhone Valley, and operates from an Alpine lake 2,150 m. (7,000 feet) above sea level. The Pelton wheels are fed by a pipe line about 4.6 km. (2.85 miles) in length. This is connected to a tunnel 500 m. (550 yards) long, which is partly under pressure. The generating station contains four wheels, each of 3,000 horsepower, which run at 500 r.p.m.

Each bucket is exposed more than eight times a second to the blow of the jet leaving the pipe at a velocity of about 180 m. (590 feet) per second. The wheels therefore had to be designed with extreme care. These wheels have an over-all diameter of 3.715 m. (twelve feet) and are of forged steel. They carry 54 buckets each and are so designed that no part either of the disk or the buckets is subjected to a higher tension than 1,000 kg. per square centimeter (14,200 pounds per square inch). Even in case of runaway this takes care of a speed 50 per cent. above normal.

Water from the feed pipe is conducted to each turbine by a cast-steel pipe 250 mm. (ten inches) in diameter, provided with a manually operated equilibrium valve. The jet pipe fixed to the bedplate under the turbine has a nozzle of tempered steel, the water discharge from which is regulated by a steel needle which moves in the axis of the jet pipe. The needle is always inclined to open when affected by the water pressure. It can be closed by a hand-operated screw, by oil-pressure mechanism or by the automatic governor. A cast-steel deflector placed between the nozzle and the bucket wheel is raised or lowered by the action of the governor, and when lowered causes a deviation of the jet away from the bucket wheel. The governing action is said to be particularly sensitive.

Rill Stoping in the Butte District

The Ideal Conditions for Adopting this Method Require Ore Veins with Approximately Vertical Dip so that Ore Will Slide to Chute

By H. L. BICKNELL

SEVERAL SYSTEMS of stoping have been used in the mines of the Butte District at Butte, Montana, depending on the shape of the ore bodies, the condition of the walls and the presence of fault zones or heavy ground. One of the recent methods tried out successfully in the past few years is that of mining using the open rill stopes. In order to give the following description of the operations involved in the development and subsequent working of the open rill stopes, the writer has made the drawings which appear in this article. In so far as possible he has attempted to make them clear and self-explanatory, indicating each detail of the timbering, mining, and filling operations There are four drawings. No. 1 shows the front elevation and side section of the first six sets of a rill stope raise. No. 2 shows a rill stope when first starting above the drift. No. 3 shows a rill stope after the preliminary development has been completed and the stope worked part way up to the level above, and No. 4 shows front and side sections of the stope illustrating the method of "sheeting" used in connection with these stopes.

WHILE THE OPEN rill stope method has been used in mines for a number of years and in several different localities there has been but little published on this subject. Therefore, in this article we give the complete details of the open rill method of stoping in one district.

The author describes the various steps including how the development is done and how the stopes are first started and carried to the level above. The advantages of this method are enumerated, particularly in the reduction of the amount of timbering needed in the stopes, and also mucking and tramming operations are cut down to a minimum. The best way of drilling a round of holes and the means of ventilation employed which reduces the chance of fire are also described.

Finally, and most important of all is discussed the method of getting out the tonnage in the shortest time and at the time it is wanted.

Geology

The copper bearing ore deposits of the Butte district occur in a body of igneous rock of large area known as the Boulder Batholith. The main rock of this formation in the Butte district was at one time a dark greyish green quartz, monzonite, known generally as Butte granite. Owing to many rock movements at various times, causing systems of faults and fissures in a number of different directions, the rocks in the area which compose most of the Butte district became very broken. Due to this fact, hot waters and gases from below and to some extent cool meteoric water from above, were able to seep through the broken area, by means of the openings through faults, cracks, and bedding planes, altering the original Butte granite and leaving a nearly white or greyish rock, with grains of pyrite of iron scattered through it. This rock is softer than the quartz monzonite. These altered zones are especially prominent being close to the oldest system of fissure veins which compose the richest bodies of ore.

The main faults and fissures of the district occur in seven distinct series. In the order of their age, they are the Anaconda or East-West Veins, the Blue Veins, the Mountain View Breccias, the Steward System, the Rarus Fault, the Middle Fault and the Continental Fault. These run in a number of different directions. The Anaconda veins strike generally east and west, the Blue Veins have a strike about N55°W, the Mountain View Breccias strike about N75°E, the Steward System of faults are northeasterly, the Rarus Fault varies in strike from N30°E to N80°E and the Middle Fault strikes about in the same direction as the Steward System.

The dips of the veins vary as a rule throughout from vertical to 60° or 70° from the vertical, and on either side in some fault systems.

Of the above systems of faults the Anaconda, Blue, Mountain View Breccias and Steward series are ore bearing. The Rarus fault which is a fairly wide system of step faults, also carries some drag ore bodies caused by faulting the ore veins.

Copper Ores

The chief copper ores found in the Butte district are chalcocite, known as copper glance, enargite, bornite and smaller amounts of covellite, chalcopyrite and tetrahedrite.

The stopes that are described in this article are in one of the oldest series of veins in the district. The walls, both footwall, hanging-wall and the vein have many small slips and faults running in a number of directions, and when exposed to the air, the walls and back soon begin "sluffing off" or breaking along these slips and cracks. Great care must be taken to keep stopes in this kind of ground properly filled. The vein is nearly vertical. The ore encountered consists of a mixture of massive (primary) and sooty (secondary) chalcocite mixed with iron pyrite in granite.

Rill Stoping

The ideal conditions under which the rill stoping method can be employed are, that the veins be narrow or moderately wide, and the ore bodies of solid, firm ore with fairly strong walls, the dip of the vein being such that the ore will slide to the chute. Vertical, or nearly vertical veins are most favorable to this method of mining.

Drifts are first driven on the vein 200 ft. apart vertically with off-sets for raises made every eleven sets of timber, along the drift, these sets having five feet four inch centers. This is shown best in Fig. 3. The twelfth, thirteenth and fourteenth sets are offsetted, then the drift is advanced another eleven sets and the succeeding three sets are offsetted again.

As the drift advances, raises are started in alternate offsets, thus leaving an offset between each two raises to be used as an ore chute later. The raises consist of two ore chutes with a manway between and are raised to the next level above, which blocks out an ore body 133½ ft. long and 109 ft. high.

Rill Stope Raises

Owing to the fact that there is quite a bit of waste rock mixed with the ore of some of the veins, and that a raise following a nearly vertical vein must be offset at times as it advances thus making it necessary to break into the foot or hanging wall, it is best in some cases to drive the raises making accommodations for sorting the ore. The lower six floors of such a raise are shown in the first illustration.

The first six floors of the raise are carried up three sets wide along the drift and two sets wide across the drift, there being a chute on each side and a manway in the center. Above the fifth floor the three sets over the drift are dropped leaving the raise three sets long and one set wide across the vein. When the eighth floor is completed the sorting chutes are built and from that time on all rock broken in driving in the raise is sorted.

Rill stope raises are always driven by contract and it is usually the custom to supply an extra man, not a contractor, to do the sorting. As this does not take all of his time he also hoists timber and supplies to the contractors.

The sorting is done as follows: A grizzly made of three or four ten by ten inch timbers five feet eight inches long is laid and blocked over the top of lower chute, No. 1. (See Fig. No. 1). The holes between the ten by ten inch timbers vary from four inches up to ten inches,

depending on the grade of rock which is to be sorted. The top of lower chute No. 2 is also covered leaving a hole about twenty by twenty inches which is large enough to permit throwing a fairly large piece of waste into the chute.

Upper chute No. 1 is then opened and allowed to run until the grizzly has become clogged with large pieces of waste. The upper chute is then closed and the waste picked from the grizzly and thrown into lower chute No. 2.

This operation is continued until upper chute No. 1 is empty. Both drift chutes are then emptied by the motor crew on the level, the ore from No. 1 chute being drawn into ore cars and pulled to the shaft, and the waste from chute No. 2 being drawn into the cars also and dumped into one of the stopes below the lower level, for filling.

It is fortunate that as a rule the waste rock breaks into fairly large pieces and that the ore usually breaks into small pieces and sand. Therefore what rock hangs up on the grizzly is usually waste and very few pieces of ore have to be broken up in order to make them pass into the ore chute.

The necessity for raises of this kind arises only when mining narrow veins or low grade veins. For wide veins containing rich ore the sorting chutes are unnecessary.

While the raises and drift are being driven, the first floor above the level between the first two raises started is mined out between these raises and timbered with square set timber. The first half of this operation is shown in Fig. 2 (Rill Stope Starting) which shows the timber in about half way between the raises. Then starting from one of the raises, cuts about eight inches high are taken into the stope towards the center ore chutes. It usually requires three cuts as shown in the drawing, No. 2, to give the back the proper angle to conform with the angle of repose taken by the waste filling as it is poured in later from the raise.

The first cut is taken six sets, the second cut, four sets, and the third cut, two sets. This is not timbered, the ore being blasted on stop boards on the first floor, enough being left in the stope, as the work proceeds, to enable the miners to drill from the pile of ore. After the cuts are finished, all of the ore is mucked out into cars through stop boards. Fig. 2, Section AA.

Stulls are used when necessary to steady the walls, as they are exposed by mucking. (See section AA, Fig. 1). The sets of the first floor are covered with a double thickness of four inch lagging as they are mucked out, to protect the miners from a fall of ground.

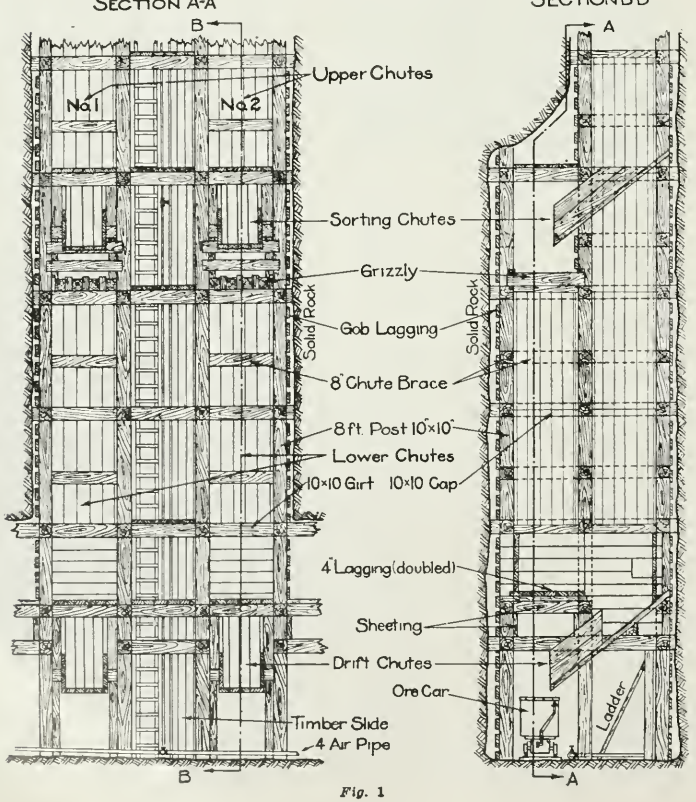


Fig. 1

Sheeting

When the ore has been cleaned out of the stope the sheeting is put in for the first six or seven sets. By "sheeting" is meant that the lagging or "roof of the drift" is raised about 30 inches above the drift caps on suitable timbers. This floor of lagging must support the weight of the filling that is used in the stope as it is worked upwards, and as the stope is carried up this weight increases. If the lagging were left on top of the drift caps, in time this load would break the caps or post, or both, and it would be almost impossible to replace them with new timber. When using sheeting, the changing of the drift timber is a very simple matter and the writer has seen many a drift post, cap or girt, and even whole sets changed during the working shift when the motor train was passing every few minutes. Without the sheeting it would be impossible. The sheeting is shown above the drift or level in drawings, Figs. 1, 3 and 4.

The timbers as used vary for different stopes and in different mines. In case, for instance, that the vein was wide or the ground was especially heavy in any section, the three inch by ten inch sheeting supports would not be sufficiently strong and four inch by ten inch sheeting supports would be used, together with five inch by ten inch lagging.

When the sheeting has been put in for the first six or seven sets to the right of the raise at the left of Fig. 2, and the two inch gob lagging nailed to the stope side of the raise timbers, as shown in Fig. 2, the raise chute next to the stope which is being started is bulkheaded at a point about five feet below the peak of the stope. A hole is cut in the side of the chute next to the stope and waste is then dumped into this chute from the level above. When the waste pile in the stope has reached to within four or five feet of the back and has assumed the proper angle of incline the filling is stopped.

The stope is then drilled from bottom to top in such a manner that the uneven portions of the back may be evened up by the blasting. After the drilling, a slide or floor, of two inch lagging, seven foot nine inches long is laid on the waste incline, the entire length of the stope and the ground is then blasted. The ore is mucked through the stop boards, more sheeting is put in, the slide taken out and the stope again filled to within four or five feet of the back; this method being continued in this way until the center ore chutes are reached and all of the first floor between the raise and ore chutes is sheeted. The peak will be at this time up to about the fifth or sixth floor of the raise. The ore will now run down the slide directly into the chute. This operation is carried on from both raises towards the center ore chutes.

The reason for taking these small cuts is due to the fact that the walls of the stope are crossed by many small slips and faults and it was necessary to keep the stope filled

to prevent caving. In stopes with good walls, the eleven sets could be mined in one operation and filled at one time without danger.

After the preliminary development of the stope is complete, the bulkheads in the raise chutes are raised to the proper levels for filling the stopes, and filling is poured in from both raises until the waste pile is within four or five feet of the back. The two center chute mouths are built and the two ore chutes and manway are raised one set and timbered.

Rill Stoping

Six foot holes are drilled in rows of two or three across the stope from foot wall to hanging wall, the number in each row depending on the width of the vein and the ease with which the ore is broken. These rows of holes are repeated every two or three feet up the stope until the entire back is drilled, all holes being perpendicular to the waste incline. It has proved to be best to keep the holes well over to the footwall side of the vein, as when too much of the hanging wall is broken it is very hard to catch up again, requiring stulls which are often knocked out by blasting or while pouring in waste filling, letting the hanging wall down again. After the drilling is completed, the slide of two inch lagging is laid on the waste incline and a four inch or five inch grizzly put over the ore chute nearest the side of the stope being mined. It is a practice in open rill stopes to blast all of the holes at one time, if possible, but in some mines the round is broken in two or three blasts. This depends considerably on local conditions.

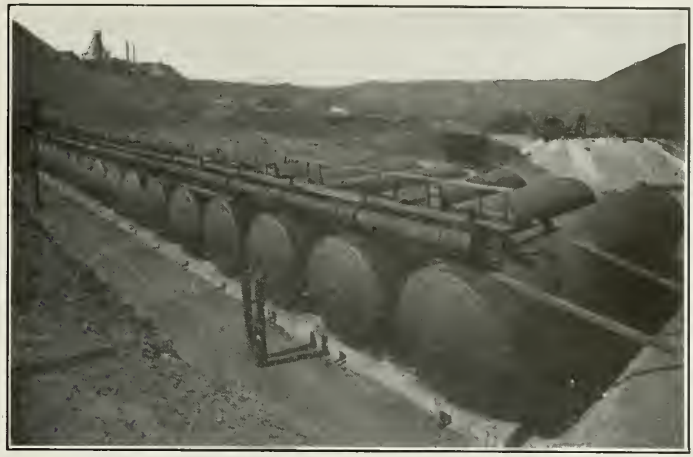
After blasting, the miners bar down thoroughly starting at the upper end of the stope and work down toward the center chutes. The broken ore is then run down through the grizzly.

In some stopes, sorting of the broken ore is necessary when the ore occurs in stringers or small veins separated by country rock, and under such conditions only one side of the stope is worked at a time, the extra chute being used for waste in the same way as it is used in the rill stope raise. The waste is picked and thrown across the manway into the far chute.

When the ore is cleaned from the stope, the slide is removed and the stope sides of the raise and ore chute are gobbed with two inch lagging and the stope is filled with waste. While the filling is being done, a cut is taken out of the other side of the stope. By alternating the work on both sides of the center ore chutes, one side can be worked while the other is being filled, which results in the backs of the two stopes being kept even.

The two center chutes and manways are raised after a cut has been taken from both sides and then the entire operation is repeated. The timber used in raising the center chutes and manway is lowered down the raises from the levels above.

In some stopes, the walls and back are heavy and "sluff" badly after the entire stope is blasted, making it dangerous for the miners, and stopes of this description are blasted daily. For such ground these stopes are mined as follows:



A remarkable series of large air receivers used for the storage of compressed air necessary to run several of the large hoisting engines.

Beginning at the center chute, the drilling is done as illustrated in the right hand stope of Fig. 2. The slide may be laid as the mining advances up the stope, or it may be laid complete before starting drilling, but it is more convenient to drill before laying the slide, as frequently a hole must be scraped in the waste incline in order to drill under an uneven back.

Enough ore is held in the stope after the first blast to permit the miners drilling from the ore pile, and as the mining continues up the stope, just enough ore is pulled to keep the ore pile within four or five feet of the breast as shown in Fig. 3, right hand stope. When the mining of the cut is complete the ore is run out, the slide removed and the stope is filled. This method of mining gives a steady daily tonnage of ore from the stope and is much safer when mining in heavy ground, as the walls are braced by the ore pile in the stope.

Cuts of six to seven feet are made in both types of stopes. In the first method, the holes are drilled perpendicular to the back and in the second method, the holes can either be drilled perpendicular or as shown in Fig. 3.

In drilling the peak ends of the stopes it has been found best to put in extra long holes in order to break the peak as high as possible. This allows the hole in the waste chute to be higher and the waste as it is dumped into the stope tends to form a steeper incline. This also keeps the waste from "hanging up" near

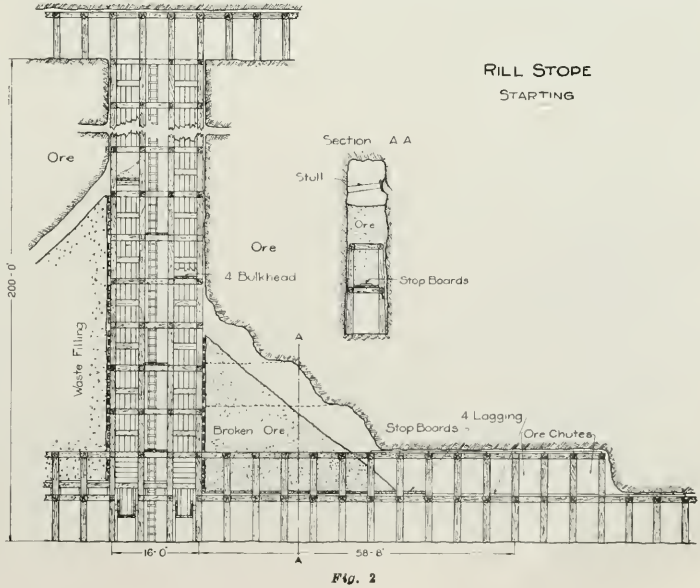


Fig. 2

the top of the stope as it can keep its velocity and will be more apt to fill the stope properly.

When the upper ends of a rill stope reach to within five sets of the upper drift, it is customary to use timber from this point. This is done by laying caps or sills on the waste incline and standing sets upon them. The sills are sunk in the waste, thoroughly side blocked and secured from slipping ahead down the waste pile by girts to the set below. After timbering, the bottom or center of the stope is mined until the stope is flattened out and it is carried to the upper level as a square set stope to prevent caving of the upper drift.

Owing to the amount of back opened in rill stopes, it is imperative that great precaution be taken in barring or trimming down the loose rock. The miners should bar down at the start of each shift beginning at the top of the stope and working down to the center chute, being sure to sound the back and walls with a bar or pick to see if they are the least bit drummy and taking the proper precautions if they are found to be so.

When the walls, or the back of the stope become heavy during the mining operation, stulls are put in to hold the walls in place.

Air and Water Lines

The large air lines are carried along the main drifts. From these main lines, two-inch air pipe is carried up both rill stope raises as they are advanced with the stope. The air line in the center raise can be used for drilling the bottom part of the stope on either side and those in the rill stope raises will supply air when the drilling is done up near the peak of the stope.

Each of the center raises has a one-inch water pipe which is used for wetting down the ore and chutes when running the ore down to the level below. When the stope is advanced so that there are six sets or more of chute in the center raise, running the ore down is a very dusty operation, due to the fact that the ventilating air is coming up the raise and it carries the dust up with it in clouds if water is not used.

The advantages of rill stoping are:

1—The only timber required is that used in the raises and center ore chutes.

2—Mucking and handling of ore is reduced to a minimum, as the ore slides down directly to the chute.

3—The filling is dumped directly into the stope and no further handling is necessary to put it in place.

4—Owing to the fact that there is no timber, the ventilation of rill stopes is more efficient. The air enters from below through a course up through both sides of the stope and thence through the rill stope raise at each end to the level above.

5—There are a minimum number of ore chutes for the amount of ore opened, lowering development costs and the cost of upkeep of the raises.

6—Levels may be placed farther apart and the development cost lowered.

7—There is very little risk from fire.

The stoper is generally used in the Butte district for both rill stoping and square set stoping, the types being the Ingersoll-Rand CC-21 and CC-11, the 16-V Waugh and the Sullivan DT-42 wet stoper.

The mounted hammer drill is also occasionally used for both rill and square set stoping, in which event the system of drilling is changed from back stoping to breast stoping.

The mounted hammer drills used are the Ingersoll-Rand 148 and 248, the Denver Rock Drill Company's Turbro and Nos. 60 and 66 also the Sullivan Machinery Company's DR-6. The custom of this district is to bring machines to the surface for repairs, with the exception of replacing water needles and other small repair parts, accurate records being kept as to the cost of up-keep.

Drill Steel

Many different sections of drill steel are being used in the Butte district, but the recent trend of opinion is towards a standard section of steel, both for the Stopehamer and the mounted type of hammer drill and the most popular section will probably be the one inch hollow steel, one of the largest mining companies here having practically adopted this steel as standard for their wet stopers. Several of the mining companies are experimenting now with considerable success in the use of this size of steel in mounted hammer drills using the anvil block chuck.

The advantages of this change over the standard Leyner shanks are so obvious that they require no comment.

Various sections of solid steel are being used in the dry stopers including one and one-fourth inch cruciform, one inch square and one inch and seven-eighths hexagon steel, but it is expected that the self-rotated water stoper will succeed the dry stoper very rapidly in this district, when it is expected that the one inch hollow steel will be used. In one independent mine the seven-eighths inch size of this same hollow steel will become standard.

The mounted hammer drills are using one and one-fourth inch round hollow lugged steel

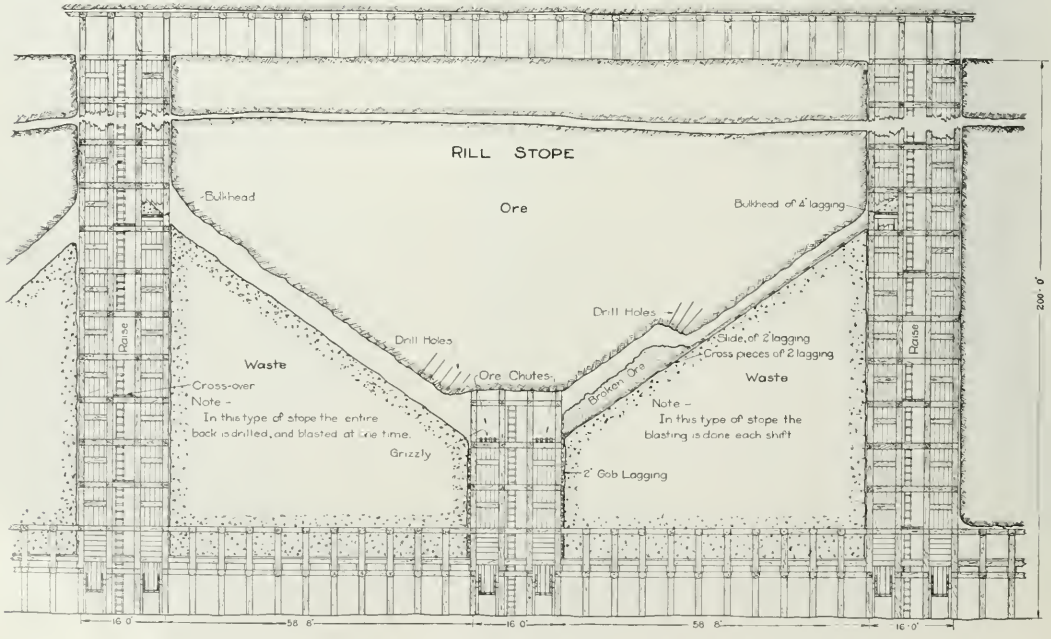


Fig. 3

A Number of Interesting Views of Mines and Equipment at Butte and at the Washoe Smelter in Anaconda

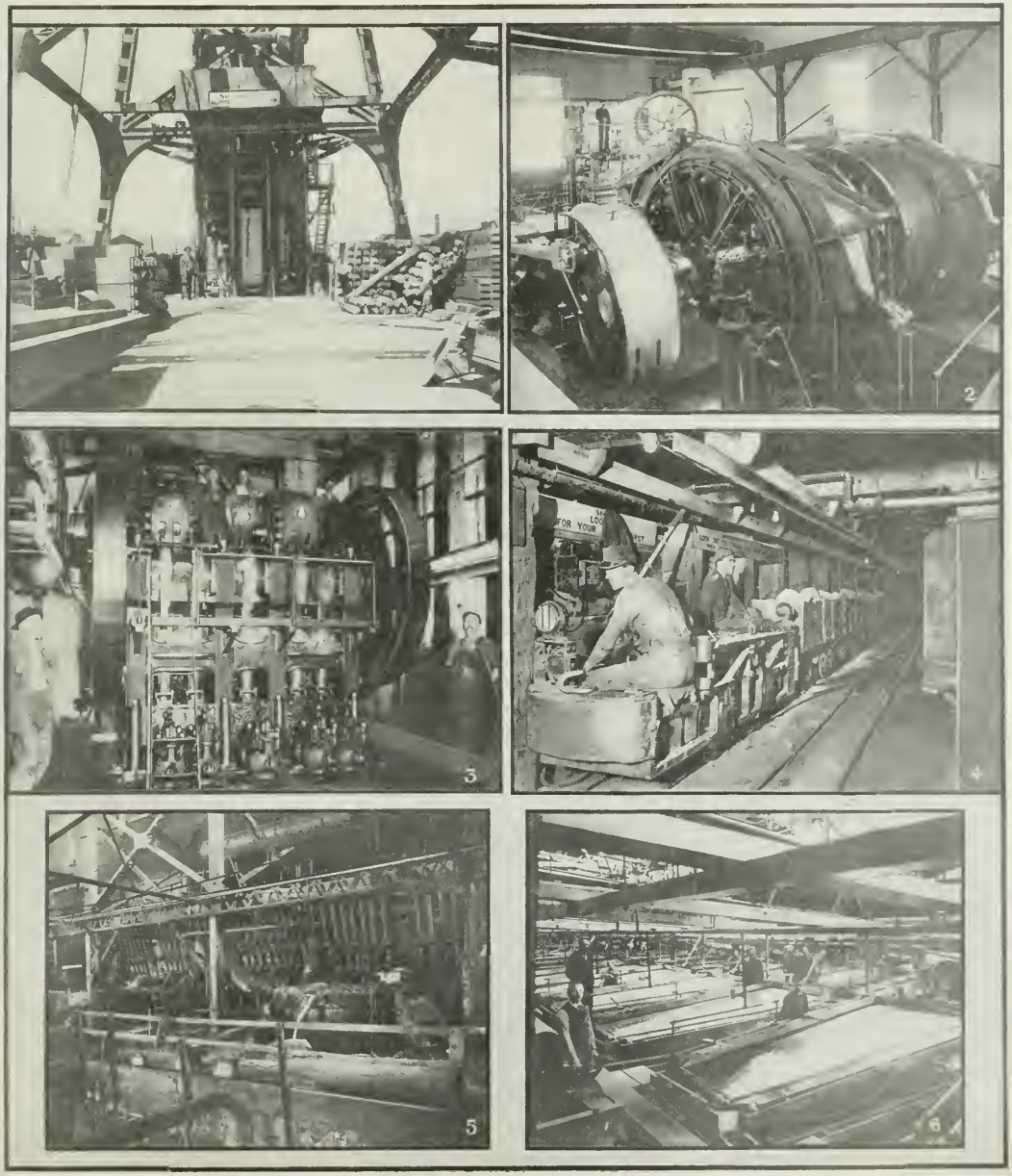


Fig. 1.—Head frame at the Tramway mine, showing piles of framed timbers, both square and round. Fig. 2.—A typical Butte compressed air hoist. Fig. 3.—Electrically driven station pump on the 1800 foot level of the Tramway mine. Fig. 4.—Electric motor haulage at the Tramway mine, Butte. Fig. 5.—Copper blast furnace, Washoe smelter, Anaconda, Montana. Fig. 6.—Concentrating tables.

generally, but it is expected that the anvil block chuck and a different section of steel will probably supersede this practice very rapidly.

The fourteen and five degree, double taper, four point cross bit is generally used in this district with the exception of the Butte & Superior Company, who use the double arc bit, the general practice being one-eighth inch variation in gage and eighteen inch changes in length for the stoping drills and one-eighth inch changes in gage and 24 inch changes in length for the mounted hammer drill steel. The bits are plunge tempered in water and the shanks hardened by covering with potassium ferro-cyanide and plunging into oil.

One of the largest mining companies in this district pays considerable attention to the sharpening and tempering of their drill bits and shanks, having a foreman sharpener who visits all of the sharpening plants in operation, with the result that their drill steel is kept in excellent condition, both as regards bits and shanks.

The practice of appointing a foreman sharpener has resulted in all instances in greatly improved bits and shanks of drill steel, with the result that we strongly recommend this practice when the number of sharpening machines in normal use is over three, whether the machines are all in a central sharpening plant or at different mine locations under the same management.

The largest percentage of steel sharpened in Butte is sharpened on the IR-5 sharpener, 40 of these machines being in use when conditions are normal and five of other types, three Sullivans and two Waughs.

The following data on drilling, in different types of stopes, raises and drifts, is taken from actual, weekly runs. The time allowed for drilling, timbering and mucking in each case, was decided by a number of men who had been in charge of the work for some time.

The time allowance for drilling includes the time necessary to set up the machine and connect the hose, the time spent in drilling, changing drills, moving from one "set up" to another and freeing any drills which might be stuck during the drilling. In fact it is the total time spent by the man or men doing the drilling during the week or the shift, as the case may be.

These figures are taken on one week's run of six working days with two men per shift and two shifts of eight hours per day. In both cases the holes were drilled in rows of three across the stope from foot to hanging wall, the rows of holes being approximately three feet apart longitudinally. By actual drilling time is meant the total time spent by one man in setting up, drilling, moving the drill, changing the steel and removing stuck drills. Ingersoll-Rand CC-21 Stope-hamers were used.

As some time during each shift was used in barring down, sorting ore, running it down the chute and laying slides to accommodate the blasting of the ore at the end of the shift, we have approximated, in this case, the actual time spent in drilling the holes necessary to break the ore during a week's run.

For example: In the first set of data on Stope No. 1, the actual time spent in drilling during the 21 shifts put in, in the stope by the men on both shifts, was considered to be nine and one-half eight hour shifts at the contract price for that week of $7.695 paid to each man for each shift that he worked.

The ground is fairly hard. Vein matter consists of chalcocite and pyrite in granite.

STOPE NO. 1.

Dimensions of stope—8 ft. wide, 83 ft. long.
Number of holes drilled—92.
Average depth of holes—5 ft. 6 in.
Number of shifts worked in stope in six days—21.
Price paid per shift per man—$7.695. Two men working per shift. Total, $15.39.
Actual time spent in drilling—9.5 shifts, 76 hours, 4560 minutes.
Tons of ore broken in six days—402.
Total length of holes drilled—506 ft., 6072 in.

$\frac{6072 \text{ in.}}{4560 \text{ min.}} = 1.331$ in. per minute drilling speed.

$\frac{506 \text{ ft.}}{9.5 \text{ shifts}} = 53.26$ ft. drilled per shift of drilling—eight hours.

$\frac{\$7.695}{53.25 \text{ ft.}} = 14.45$ cents per foot drilled or 1.204 cents per inch drilled.

$\frac{402 \text{ tons}}{9.5 \text{ shifts}} = 42.3$ tons per shift (8 hours) of drilling.

STOPE NO. 2.

Dimensions of stope—8 ft. wide, 75 ft. long.
Number of holes drilled—80.
Average depth of holes—6½ ft.
Number of shifts worked in stope in six days—24.
Price paid per shift per man—$7.11. Two men per shift. Total, $14.22.
Actual time spent in drilling—11 shifts—88 hours, or 5280 minutes.
Tons of ore broken in six days—408.
Total length of holes drilled—80x6.5 = 520 ft., 6240 in.

$\frac{6240 \text{ in.}}{5280 \text{ min.}} = 1.182$ in. drilled per min.

$\frac{520 \text{ ft.}}{11 \text{ shifts}} = 47.3$ ft. drilled per shift.

$\frac{\$7.11}{47.3 \text{ ft.}} = 15.031$c per foot drilled, or 1.253 cents per inch drilled.

$\frac{408 \text{ tons}}{11 \text{ shifts}} = 37.1$ tons per shift of drilling.

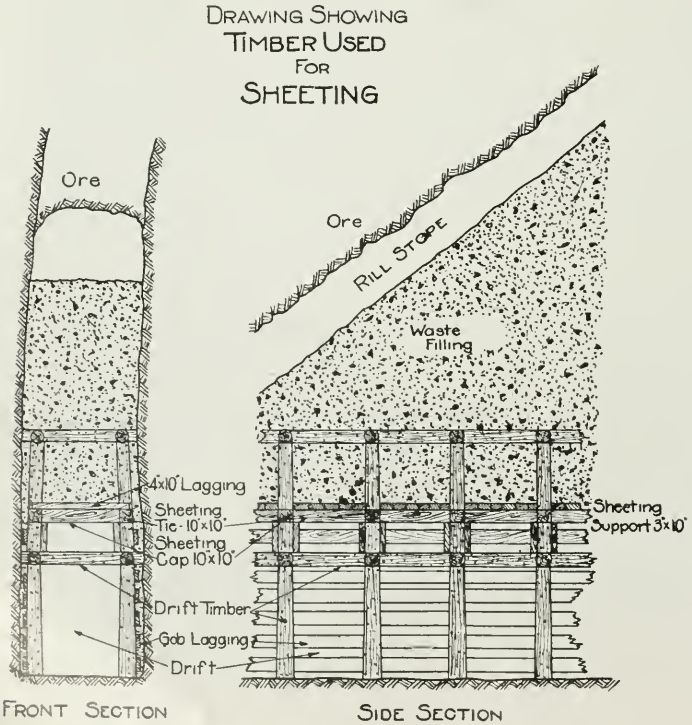


Fig. 4

COAL SLIDE ENTOMBS MINERS

A recent slide of hundreds of tons of coal and rock, which entombed two miners, occurred in the Kaska William colliery of the Alliance Coal Company at Middleport, near Pottsville, Pa. A gang of rescuers under inside foreman E. C. Hahnes drilled a passageway, 3 ft. 6 in. square with Jackhamer drills for a distance of 22 feet without a shot being fired. They drilled the bottom bench full of holes, then took picks and excavated the material out. This was performed in 25 hours' time, one man being saved but the other one was found dead.

The new bridge being built to cross the Connecticut River and connect the cities of Springfield and West Springfield, Mass., is progressing rapidly. This is one of the largest bridges built since the war, the total length being 1429 feet. This includes a viaduct of 300 feet which crosses the tracks of the N. Y., N. H. & H. R. R. on the Springfield side of the river.

Compressed Air Used in Removing Pavement and General Demolition Work

AMERICAN PROGRESS seems to be measured by the substitution of efficient mechanical methods for costly hand methods in every field of endeavor. You have no doubt seen several gangs of three or four men each, cutting pavement by the old hand methods. One man would hold the chisel and the other two or three would strike with eight-pound hammers. This was hard work. The progress made by these gangs, if they worked continuously, was slow but they did not work continuously. To estimate that 25 per cent. of the time was lost in resting, talking and lighting pipes would be conservative. A new method for removing pavement of all kinds and for demolishing all types of masonry and concrete has been perfected by the Ingersoll-Rand Company.

The principal feature of this new method is that the work is done rapidly by efficient compressed air operated machines instead of by slow, laborious and costly hand work.

The field of the method is almost unlimited: electric power companies may use it for tearing up the pavement for the laying of electric cables and service lines, gas companies for laying gas mains, street railway companies in the laying of new tracks or the repairing of worn tracks. Wrecking companies and industrial plants use the method for demolishing various types of structures and foundations. It is also used in smelters and refineries for removing the slag in reverberatory furnaces.

Until lately all of this work was done by hand and even now much of it is being done by hand. However, a number of companies have standardized on the new methods and machines. By doing this they have reduced the cost and time of this work amazingly. One case on record shows a cost saving of about 67 per cent. and a time saving of about 75 per cent.

The "Paving Breakers" themselves are very similar in construction to the most modern non-rotating type of hand hammer rock drill. They are extremely simple and rugged and are all steel machines, principally dropped forgings, so that they will stand the most severe usage encountered in their work. They are "one-man" machines.

Two "Paving Breakers" are operated by compressed air furnished from one small portable gasoline or electric driven compressor. A great deal of the success of the machines and the methods itself, must be accredited to the great improvements incorporated in the portable compressor or, more correctly speaking, compressing outfit. The portable outfit consists not only of the compressor but also of the prime mover which is either a gasoline or an electric motor; a cooling system consisting of radiator, fan, and circulating water pump; and receiver tank, all of which are mounted on substantial steel frame, which in turn is mounted on broad thread steel wheels so that the entire outfit may be quickly and easily transported from place to place. The reader has certainly seen many of these compressors being used for road construction and general contracting.

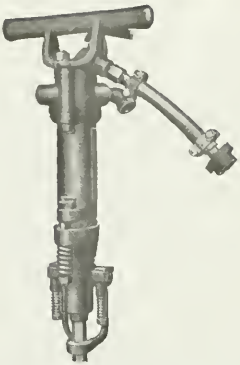
Following is a comparison of the machine versus the hand method and the tearing up of an asphalt pavement for the concrete subbase for the laying of electric cable duct:

A very good crew of eight men using hand methods will cut about 80 linear feet of eighteen-inch to 24-inch width asphalt and concrete in an eight-hour day. The asphalt averages three inches to six inches in thickness and the concrete about six inches. That means ten feet per man per day, or 50 cents per linear foot at a $5.00 wage. Three men with a compressor and two "Paving Breakers" cut an average of 300 linear feet per day. This costs about sixteen cents per linear foot when wages, operating cost, interest, depreciation, etc., are all taken into consideration. In other words, a saving of two-thirds in cost—and the work is done in about one-quarter of the time.

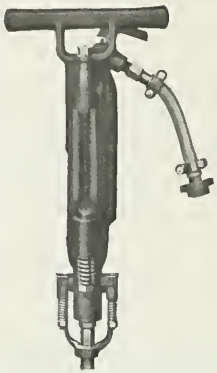
The above figures are not estimated. They were furnished by a large Eastern public service company which uses four of the above

"Paving Breakers" cutting trench for the laying of pipes and electric cable ducts.

Illustrating the application of "Paving Breakers" on electric street railway work.



Type BC-25 "Paving Breaker."



Type CC-25 "Paving Breaker."

Ingersoll-Rand Type 14 portable compressor mounted on an electric truck for getting around to one small job after another at different locations.

"Paving Breakers" destroying concrete and masonry for the enlarging of man-hole, Compressed air furnished by Type 14 Portable Compressor in background.

mentioned outfits. They say that each outfit pays for itself every month—and their statement is backed up by figures.

These machines have another feature which appeals to this company. It pays its men who are on this work whether it rains or shines, yet, it does not expect the men to work on rainy days. One of the officials stated that the compressor saves them $75.00 every day it rains, because, if they were using the old hand method, there would be fifteen idle men around the shops.

One of the uses the Los Angeles Railway Corporation has for the "Paving Breakers" is the cutting of openings on either side of the rail through 6 in. of concrete, having a covering of 2 in. of asphalt. These openings are about 23 in. long and extend 17 in. on each side of the rail. Under the old hand method four men with a gad and hammers would not be able to do more than three of these openings a day. Two men with one "Paving Breaker," cut 22 of these openings in nine hours; that means that one man using mechanical methods replaces fifteen men using hand methods, and these men are paid $4.35 each. This work is being done on a track, which is being discontinued. The openings are made in order to give gripping place under the rail for hydraulic jacks by means of which the rail is pulled out.

As an example of how the work is done, let us take the above public service company's job. The other types of work are so similar that this will suffice to cover all.

This company has four 6 in x 6 in. Ingersoll-Rand Type 14 portable gasoline driven compressor outfits. Each compressor operates two "Paving Breakers" working continuously. The crew consists of three men (compressor man and two drill runners). The compressor man is in charge of the crew and relieves the drill man from time to time. These outfits are used for tearing up the asphalt pavement and the concrete sub-base for the purpose of laying cable ducts. They are also used for breaking out masonry for the enlarging of manholes.

In laying cable and service line ducts, stretches of pavement 18 in. to 24 in. wide and varying from 25 ft. to 300 ft. long, (and in rare cases even longer) must be removed. The duct is laid about three feet below the street surface. This means the removal of a 3 in. to 6 in. thickness of asphalt (the asphalt is exceptionally thick), a 6 in. to 8 in. thickness of very dense concrete and, finally, about two feet of dirt.

The chisel bit is driven through the entire thickness of the asphalt at intervals of about 3 in. to 4 in. along two lines 18 in. to 24 in. apart. This is termed "marking" the asphalt. This "marking" has really the same effect as two parallel grooves. The ends also are "marked." Then the chisel is driven nearly vertically through the full thickness of the asphalt about 12 in. from one end of the job. This breaks a piece about 12 in. by 18 in. of the asphalt off from the main body. Sometimes one cut is necessary to remove a piece this size—sometimes as many as four cuts. It takes only a few seconds to make these cuts.

As the asphalt is broken, it is removed by hand by the relief machine operator.

Now we come to the concrete sub-base which averages about 6 in. in thickness. The moil point steel is substituted for the chisel edge steel in the "Paving Breaker."

The moil point steel is driven through the compact sub-base. First it is driven in about the middle of the trench, that is, 9 in. from either side. This spalls off an irregular "V" shape piece, then two more cuts are made one 3 in. from each side which removes the remainder of the concrete along that line. The average is about 3 in. for three cuts.

After the concrete has been removed, the dirt beneath it is loosened up by driving the moil point steel into it for its entire length. The dirt is then shoveled out by hand until the trench is about 3 ft. deep. Then fiber cable ducts are laid end to end and are completely bedded in concrete. Finally the trench is covered and repaved. Man-holes of various sizes and shapes are made at different points and the cable is run through the ducts from one man-hole to the other.

STORING AND DISTRIBUTING GREASE BY AIR PRESSURE*

By F. J. EAGER

IN VARIOUS MINING and smelting operations quite large amounts of the different oils and greases are used, and the supplies are commonly stored at central points from where they are issued daily in small quantities. For the purpose of storing and issuing oils, several excellent tank and pump systems have been developed. By these means the different oils may be conveniently stored and issued in a clean and efficient manner. The greases, however, are by their nature more difficult to handle and I do not know of any devices by which they may be handled in similar ways.

This difficulty became very evident some time ago when the underground drill was changed from the piston to the Leyner type. It then became necessary to use grease as well as oil for lubricating the drills, and small quantities of grease had to be issued daily to each drill-runner.

The drillers take the grease into the working place in what we call "grease guns." The guns hold sufficient grease for a working shift, the grease being forced from the guns into the drills. At first the grease was allowed to remain in the original container, either a tub or a barrel, and filling the grease guns was a slow and dirty operation. It was accompanied by quite an appreciable waste and the grease often came in contact with, and picked up, dust before it was introduced into the drills.

To overcome these difficulties we have devised a machine by which, with the aid of air pressure, all the lighter grades of cup greases can be handled as easily, as efficiently, and in as clean a manner as is the case with the oils. The details of this machine are shown on the accompanying drawing.

The device has three essential parts: The first is the grease container, which is a bored iron cylinder, inside of which there is a piston without a rod. This piston is built up from three steel plates and two leather packing-rings and travels from the bottom to the top of the cylinder. The second part of the machine is the grease distributing system, through which the grease is piped from the top of the grease container to the different discharge-openings. These openings may consist of taps of any desired form of discharge opening. In the machine in question the grease is forced to a manifold pipe, which is fitted with a number of 3/8-inch couplings to which the grease guns are screwed for filling. The third part of the device is the operating arrangement. This consists of an air pressure line that enters at the bottom of the grease container. This line has an operating valve and also a pressure release valve. The latter is placed between the operating valve and the grease container. At the left of the drawing will be seen a section of flexible rubberhose that terminates with a union.

The device is used in the following manner. The grease container cup is removed by unscrewing. With the piston at the bottom of the cylinder, the container is filled with grease. In this particular machine, the container has an inside diameter of twelve inches and is about twenty inches in height. It holds about 60 pounds of grease and therefore takes quite easily the contents of a 50-pound tub. This charge will fill from 125 to 150 grease guns. After filling the container, the grease-pipe is attached and the machine is ready for use.

In the regular routine all the grease guns are filled at one time. In this case ten can be filled at one operation. For instance, a grease gun is attached to each filling plug, while all the filling plug valves are open. The operating valve is then opened and the "guns" are quickly filled. In case fewer than the total number of plugs are to be used, the valves of the other filling plugs are closed. Before unscrewing the grease guns, after filling, the pressure on the grease is relieved by closing the operating valve and opening the pressure release valve.

When the grease container becomes empty, the grease pipe is disconnected at the union at the top of the container. The rubber hose is then attached to the above opening and the valve on the hose line is opened. This returns the piston to the bottom of the cylinder and eliminates having to introduce a dirty implement of any kind into the grease container. The container can now be refilled, after which it is ready for further use.

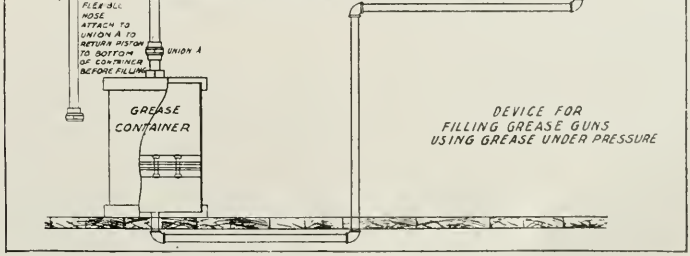
This arrangement is very satisfactory for handling and issuing grease. The device is practically fool proof, it never gets out of order and there is nothing to wear or to be easily broken. For the purpose for which this arrangement has been designed, the quantity of grease used at one time is not large, but the device works so freely that it is not easy to see why much larger quantities of grease could not be stored and drawn off in the same manner. Taps could be used and the grease drawn off in much the same way as we handle oil through tanks and pumps.

*Paper before the Canadian Institute of Mining and Metallurgy.

POTASH OUTPUT IN 1920

A hopeful increase in the production of potash of the United States has been noted in the Geological Survey covering the output of that product. In 1920 the number of tons of crude potash produced were 167,346 and 75% of this came from the lakes in Nebraska and other places. The remainder was extracted from distillery waste, alunite, dust and other sources. Progress was impeded to a considerable extent owing to handicaps, and the call for it as a fertilizer suffered because of adverse economic conditions.

In 1920 the total value of exports from Rio de Janeiro to the U. S. was $34,568,557 as against $38,000,092 in 1919. Although numerous products enter into this trade, the shipments of the four leading products were:—coffee, manganese ore, sugar cane and cattle hides.


GALVANIZED LINED TRAY
PLUGS FOR GREASE GUNS
FILLING VALVE
PRESSURE RELEASE VALVE
GREASE PIPE
FLEXIBLE HOSE ATTACH TO UNION A TO RETURN PISTON TO BOTTOM OF CONTAINER BEFORE FILLING
UNION A
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EDITORIALS

A NATIONAL REMEDY FOR INDUSTRIAL ILLS

THE RECENT address delivered by MR. WILLIAM L. SAUNDERS at the Annual Meeting of the Chamber of Commerce of the United States, and published in the June number of the *American Exporter* and the *Nation's Business,* clarifies to a considerable degree a number of important factors at present involved in the international situation.

Aside from the tariff phases of the situation, which MR. SAUNDERS presented in detail, he made several significant suggestions concerning some of the vital factors having to do with stimulating and maintaining national prosperity. In fact, they deserve most serious consideration as to their essential economic importance.

There should be much food in them for mental assimilation among the legislative leaders of our country. "The building of a dozen Panama Canals, if undertaken to-day," said MR. SAUNDERS in the course of his remarks, "would promptly set the world on its feet by creating a buying power. This is why business boomed and prices and wages went up so rapidly during the war. Nations with ability to buy went into the markets in such volume that the power of buying was greater than of selling. To-day the reverse is true, and therefore everything is falling. We may increase consumption by either reaching out for new markets or by reduction of price, or both."

The application of this principle to the building of the Great Lakes—St. Lawrence waterway, frequently discussed in the editorial columns of the COMPRESSED AIR MAGAZINE, would seem pertinent. The undertaking of other great national projects such as the development of the water power resources of western America could also be included in MR. SAUNDERS' suggested remedy. Supplies of all kinds in immense quantities for these projects would be required and would cause numerous machinery manufacturing establishments to run full time which would ameliorate the labor reduced condition prevailing and result in establishing for the citizens of America a lower cost of living. In other words, the cycle of prosperity from purchaser to consumer would be completed, and everybody,—capital, labor and the public—would be contented.

It is not impractical in any sense, providing political obstacles are not placed in the way. MR. HERBERT HOOVER, at present holding the position of Secretary of Commerce, and nationally regarded as one of the ablest men in PRESIDENT HARDING'S cabinet, has frequently shown in his public addresses, that he favors such national developments, and this will be one of his guiding policies in the program of bringing back normal conditions. He has advocated the Great Lakes-St. Lawrence waterway, and is favorable to the development of a vast central power zone, with an inter-connected system of power transmission covering the region north from the District of Columbia to the southern parts of Vermont and New Hampshire and extending inland from the seacoast for distances ranging from 100 to 500 miles. This is but the simple truth about a vital economic principle that we may increase consumption by creating new markets.

FRANCE UTILIZES "WHITE COAL" RESOURCES

THAT PORTION of France which was ancient Dauphiné, annexed to the French crown in 1349 under the rulership of PHILLIPPE IV, although long geographically known as the province of Iserc, is nevertheless almost invariably referred to by all manner of French people as the land of its ancient name. Situated in the southeast, it touches the valley of the Rhone on the west and north, and the mountainous province of Haute Alpes and Savoie on the south and east. Scenically it is one of the marvels of France.

Through economic exigencies born of the Great War and highly developed since the armistice, this historic and picturesque section is acquiring yet another name—*Le Pays de la Houille Blanche;* or in prosaic English, The Land of White Coal.

For in Dauphiné throughout all the centuries, "white coal" has existed, gushing over rock and cascade, waiting to be utilized industrially that wheels might turn and looms spin now that cannon need no longer be forged through its potency. It was only in 1915, and because coal in inadequate quantity was impossible of securing for local use, that the numberless white and frothing torrents and cateracts of Dauphiné, watered as they are through the eternal snows of the French and Italian Alps, were first adopted to commercial purposes, commercial in the sense that their great natural energy wasted for centuries, was partially leashed for the manufacture of war equipment.

Out of this has come in times of peace, a fascinating evolution in methods of securing power, budding to grow to very great proportion as the years roll by.

It was in and about Grenoble, a city of perhaps 300,000 inhabitants, and the metropolis of Dauphiné, that French industry established itself centuries ago when time was but the passing of hours, and overhead charges an unknown quantity. Armor was made in Grenoble, skillfully and marvelously as early as 1240, paper of the finest quality from 1450, woven fabrics in wool and linen from about 1700, and silk rivaling that for which Lyons is famous, from about a century later.

During the last half of the nineteenth century, these last three industries had grown to international importance, playing an important role in the economic history of France.

From 1850 to 1900, Grenoble and the surrounding districts, grew famous for glove making, taking the foremost position in the world in this industry through a perfection of workmanship. In the same relative period, workers in many branches of the metal trade, and in particular, the manufacture of plain and decorative metal buttons added their goodly quota to the industrial importance of Grenoble and France. From about 1860, the great quantities of fine oak that had long abounded in Dauphiné, invited manufacturers of interior woodwork and furniture all of superior workmanship.

Each and every one of these divers industries, were dependent upon the indispensable first essential of coal, much of which was mined in Dauphiné where 300,000 tons were taken out yearly, and until 1910 inclusive, burned to the extent of 60 per cent within 100 miles of its origin. Meanwhile, mountain torrents rushed foaming white upon their continual way, one with a sheer drop of 4000 feet, many others in drops of from 100 to 1500 feet, still many others of lesser importance, all wasting their natural power, but picturesque adjuncts to the natural beauties of a beautiful country; and no more.

In 1911, four manufacturers became pioneers in the harnessing of water energy, and to the surprise of many who ridiculed their innovation, continued upon their manufacturing way successfully. At the outbreak of the war, exactly eleven manufacturing establishments in and about Grenoble utilized water power, a yet tiny minority among a mass of sceptical brethern.

The average Grenobleite, as indeed the average Frenchman before the war, decried innovation, remaining content to follow in the footsteps of his fathers; a significant fact which is one of the main reasons why Germany made remarkable headway through many French inventions—for example, the use of by-products of coal in making dyes.

Every one of the eleven plants in question were close to water energy, using the power "raw" so to speak, securing it upon the old-fashioned principle of a grist mill drive whereby a maximum of water falling from a height centralized within a minimum of revolving wood or metal, that in turn moved machinery.

In late 1914, the exigencies of war became the incentive to rapid progress in the control of this natural power. Plants were hastily erected upon advantageous sites regardless of proximity to water falls, and pipes connected with a long waiting power for the generation of electricity.

In late 1915, sixteen important plants were in operation, all electrically driven generated from water power. Each of these sixteen were manufacturing shell case and artillery parts. At the time of the armistice, 67 such plants were in feverish operation, and it is not an untruth to state that the product of Grenoble and its surrounding districts contributed in no small percentage towards German capitulation.

Since the armistice, every establishment of any importance in the district has its machinery electrically driven through water power as a parent force.

Statistics compiled in late 1920 show that the equivalent of 610,000 horse power is now utilized in the metal, button making, and kindred industries, 400,000 horse power involved for light and traction purposes in Grenoble and within 200 kilometres area, that the chemical industries utilize a trifle more, the wood and paper industries nearly 300,000 horse power, and all other industries, 300,000 additional, a grand total of 2,150,000 horse power all derived from the natural water falls of the section. The coal from Dauphiné is sold "in another country" as is designated any other province, in a proportion of 80 per cent. of output.

There are existent within the district 90 generating plants, working in some instances 24 hours daily in three shifts. In addition to the power utilized as above mentioned, these plants light not only Grenoble but every town and village in Dauphiné where a factory exists. They drive all the trolley and tram cars in the province, and some without its boundaries. They are in a relatively small percentage, heating houses and factories, small, because innovation in that perspective has not yet been digested by the inhabitants.

There is a slow but sure increase, however, in this direction, and it is quite within the bounds of possibility that within half a century, all the province will be heated as well as lighted through the initial power of white coal. Villages that have no other modern commodity are lit by electricity, and at periodical points upon the State highways, arc lamps beam upon the passer-by. It is all the more remarkable because in practically every other respect, the province is keeping to old methods, utilizing means and ways that were good enough in the old sleepy days of yore.

Yet despite the quantity in use, much of the white coal in Dauphiné remains unshackled to the usages of man. There are hundreds of thousands of horse power still pouring frothingly over rock and mountain crevice, still wasting centuries old energy. With certain steady increase it will be in large percentage directed to human use as is exemplified through the present study of a project whereby the white coal of Dauphiné is to be piped 500 kilometres for generating electrical power in an important plant in the centre of France.

It has been calculated in this particular respect that even after the initial cost of piping is paid for, the yearly saving through elimination of the black brother mined from the earth, dependent as he is upon war and freights, among other hazards, will be fifteen per cent.

HOW SMELTING NICKEL WAS SOLVED BY AN ACCIDENT

A story told by A. J. Wadhams, assistant general superintendent of the International Nickel Co., of Bayonne, N. J., and recently published in a press bulletin issued by the Engineering Foundation, New York, relates to the manner in which nickel steel came to be introduced into modern industry. In the early '80's, says Mr. Wadhams, a paper was printed in London on the possibilities of nickel steel and later created considerable interest in the United States.

At that time there was a bad yellow-fever epidemic in New Orleans. Some one suggested that it might be stopped by isolating the patients and keeping them at a low temperature. A hospital ship equipped with refrigerating apparatus, moored in the Mississippi River, was the plan decided upon.

Some studies of refrigerating machinery showed that one of the difficulties was to get a metal which would withstand the corrosive action of ammonia gas. The committee of Congress which had the matter in charge decided that the new alloy known as nickel-steel was the best metal. Thereupon bids were sent out for nickel. It was found that the world supply of nickel, which up to that time had been used principally for coinage, was so limited that some new supply would have to be found to meet the demand.

Col. R. M. Thompson, at that time proprietor of the Orford Copper Company, had on his hands a so-called copper ore, from the Sudbury district of Canada, which he found contained a substantial amount of nickel. There were no known methods about 1880 for separating nickel from copper as found in these ores. Here was an ore which contained the nickel the Government wanted for the hospital ship but no way to get it out. Having, however, the courage of his convictions, Colonel Thompson went to Washington and agreed to supply the nickel.

A small blast-furnace, through which these ores were smelted, was tried with every known flux which could be brought to Bayonne, N. J., with no results. Finally it was agreed that the general accumulation of miscellaneous ores, fluxes, and other materials had better be cleaned up before any further attempt was made. In the process of cleaning up Colonel Thompson had pointed out to him by one of his superintendents a pot of metal which had separated when dumped. No serious thought was given to this incident, but it was sufficiently suggestive to lead to sampling. The result showed the nickel in the bottom and the copper in the top.

The question then was, Which and what of the ingredients put through the blast-furnace, in the proces of cleaning up, were responsible for the result?

By a process of elimination the proper combination was established. This separating process was known from that time on as the "Orford Process."

THE EDISON QUESTIONS ON THE USE OF AIR

THE WIDE discussion which has been provoked by the publication of the list of questions prepared by Mr. Edison for the examination of candidates seeking employment under him suggests that there must be something in them after all. Like other Edison devices proposed for a definite purpose, it may be assumed that they satisfactorily accomplish the purpose intended.

The historical and geographical questions, and some perhaps in physics, which could be answered catagorically, tested the range of general reading and the retentive powers of the memory. Some of the questions were of quite a different character and challenged other mental characteristics. Some indeed could only be regarded as catch questions, or could only be answered by a more or less labored explanation which would serve to exhibit many qualifications, or otherwise, in the candidate.

Rather curiously, there are at least two questions in the list which should be of special interest to readers of Compressed Air Magazine and which it might be well for them to try to answer. One of these is, on the face of it, very simple: What is the weight of air contained in a room 20 by 30 by 10 feet? The cubic contents of the room thus being 6,000 cu. ft. we have only to know the weight of one cubic foot of air and multiply it by the 6,000 to obtain the answer.

But to secure a result of any practical value in a specific case several variables would have to be considered. Nothing is said about the location of the room, which might be at sea level or at a considerable altitude, the pressure of the air varying accordingly and the weight of any volume increasing or decreasing with the pressure, so that, for instance, other conditions being identical, the weight of the air in the room at, say, Denver would be decidedly less than the same roomful at New York. And then, also, the other conditions spoken of would not be identical but would be subject to constant change.

There would be the temperature, which we know is everywhere so unstable, and which

has so great effect in determining the relative and actual volume, pressure and weight of the air; and in the correct use of this factor the distinction between the absolute and the thermometric scales would be brought into prominence.

We may assume that up to this point only dry air has been considered, but the question of humidity cannot be ignored. Air, as a matter of fact, never is dry but always carries more or less water vapor which always changes the weight per volume, and this also must come into the computation. Here will be struck the curious paradox that the more aqueous vapor there is in the air the lighter it will be, up to the point where it is just saturated, when it will be lightest of all.

It is not easy to imagine how Mr. EDISON could well have devised a better question than this of the weight of the air contained in a room of given size, assuming that the student would recognize and deal with all the conditions involved.

The question, what is a caisson? is quite a simple one, but we would pity any candidate who could not have prepared a better answer than that which has been invented by the newspapers: "A caisson is an enclosure to keep water from seeping or flowing into a space where engineering operations are taking place." Why, that is a coffer dam and does not describe a caisson at all.

The word "caisson" has various and diverse applications. We have to assume here that a pneumatic caisson is intended. This is simply an open ended inverted box or shell which is lowered into water or water-bearing material, men working within it to excavate and remove the earth and allow it to sink to bedrock or to a prescribed depth and the water being excluded by a pressure of air within. When the excavation is completed the caisson is filled with concrete and remains permanently for a foundation for some superstructure, or similar purpose. Something like this we would have tried on Mr. EDISON, with possibly more elaboration.

TEMPERED COPPER NOT A LOST ART

That tempering copper is numbered among the lost arts is a prevailing impression in scientific circles but the Bureau of Standards calls attention to the fact that hard copper is employed in considerable quantities in a variety of ways and furthermore, new applications are being constantly found. The soft metal may be hardened by mechanical treatment, as in hard-drawn wire, or by alloying with other metals. Experimenters frequently "rediscover" tempered copper by fusing the oxide in with the metal, making a very hard but brittle alloy.

According to a report from the Concepcion district, Chile, Japanese capitalists, the Sociedad Furukawa, have sent a commission of engineers into the interior of the Province of Bio Bio to investigate the copper mines there, known as Los Chenques, Quenco and Santa Ines, which it is reported produce ore containing 4.75 to 6.11 per cent. of copper.

A COMPRESSOR TROUBLE NOT IN THE COMPRESSOR

THE FOLLOWING interesting story is told by Mr. C. A. Green in *Power*, in a recent issue..

Among the four air compressors in my charge are two 900-cubic feet per minute, two-stage machines with Corliss intake and poppet discharge valves, driven by 440-volt three-phase slip-ring motors; both compressors and motors are identical. One unit had been run about three and one-half years, the other about four months. We had never had any trouble with the older machine. For about six weeks the new machine behaved as it should, and then the trouble started.

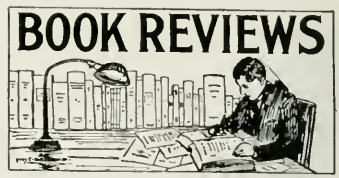
These machines have a short belt drive with a floating idler. One morning on starting the new compressor the idler began to jump violently as soon as the unloader cut the machine in on the line. As the belt did not appear to be slipping, this action suggested a sticking discharge valve. The discharge valves were examined, but no carbon or gummy deposits were found. They were cleaned thoroughly and the machine then started properly and ran satisfactorily for a couple of days.

Another morning the idler began jumping so violently that the surge tripped the circuit-breaker on the motor. The valves were again cleaned and the trouble vanished, only to appear again two days later as bad as ever. This went on for about two months. We changed the compressor cylinder oil, examined all parts of the compressor and found nothing wrong.

Sometimes we would take out one or two valves, clean them, start up and go all right for a day or two; then taking out the same valves had no effect. Finally, we took to cleaning all valves every night after shutting down, and for about a week had no trouble. We had about come to the conclusion that the oil was responsible for our troubles when, on starting with the valves all clean, it was there worse than ever. On but one occasion had we any trouble after the machine was well warmed up, and this was when the machine had been running about 30 hours.

Three experts from compressor builders examined the machine and could find nothing wrong. Then I had a "hunch" that perhaps the surge of the machine when loaded might affect the contacts in the motor starting box, which was mounted on the motor base. Upon removing the cover from the drum-type controller, a poor contact was found on the fingers that short-circuit the slip rings when the motor is up to speed. The contacts had been hot, and some of the solder had melted out of one of the terminal lugs. When this was repaired, the machine started properly and has run satisfactorily for months.

A company is being started at Belgium to exploit papyrus, which grows in large quantity in the Belgium Congo, near Elizabethville. Analyses showing 37.8 per cent. cellulose have been made. A bleaching process has been discovered and a concession has been granted this company to put up a plant at a cost of 2,500,000 francs, the plant to have a production capacity of 20,000 tons of pulp.



COMPRESSED AIR, a Treatise on the Production, Transmission and Use of Compressed Air, by THEODORE SIMONS, E. M., C. E., professor of mining, University of Montana, School of Mines. Second edition; 173 pp., $2. New York and London: McGraw Hill Book Co.

THIS VOLUME is intended to treat the subject in a general way and give the student an insight into the natural laws and physical principles underlying the production, transmission and use of compressed air in order that he will comprehend the operation of the various appliances.

No attempt is made in the book to go into an extensive description of the different types of compressors or other pneumatic appliances. The author tells us his chief aim has been to provide the student with a background of understanding that will enable him not only to solve the many theoretical problems connected therewith, but to make independent research into the seemingly unlimited possibilities of compressed air. The territory still unexplored is vast and full of promises to the explorer who enters the field with a thorough knowledge of all the truths discovered by those who have gone before him.

The work will be found well within the mental capacity of the average technical student who has a sound knowledge of the elements of algebra, physics and mechanics. Higher mathematics are used sparingly and only when necessary.

HYDRO-ELECTRIC DEVELOPMENT IN ONTARIO, a history of water power administration under the hydro-electric power commission of Ontario, by E. B. BIGGAR, author of "Canadian Railway Problem," former editor of *Canadian Engineer*. Illustrated and indexed; 202 pp. Toronto, Canada: The Biggar Press, Ltd.

THIS VOLUME deals with a very important development in modern industrial life, namely the utilization of natural water power resources. It tells the story of the Hydro Electric Power Commission of Ontario, which has become the largest generator and distributor of electric energy in existence and as we are told in the preface this commission has already accomplished results worthy of a province whose hydraulic power resources are in some respects unique.

This work discusses the future of the great water powers of Canada, especially the waters of the Niagara and the St. Lawrence. It is predicted that the power of the St. Lawrence will be harnessed to full capacity and that the rivers of the great northland will begin to do service for the millions of Canadians in a day not very far distant. We are told that a gallery of power stations utilizing the lower Niagara River will serve the wants of a third of the population of the continent. Already three other provinces—Manitoba, Nova Scotia and New Brunswick, have followed the leadership of Ontario in creating

power commissions. A short account of these will be found in the appendix. The state of New York is moving in an uphill fight in the same direction. In the United States at large, water power development under public protection has been stayed by the more or less conflicting action of the three federal departments—the Interior, Agriculture and War—among whom the control has heretofore been divided, but such conflict has been ended by the establishment of a Federal Power Commission composed of the secretary of each department, and a trial is being made of a system of water leases which will at least safeguard this great natural resource from further alienation. Hydro-electric power development will now proceed more rapidly over the whole continent, and in the coming era the crown of honor will surely be awarded to the little band of municipalities whose faithfulness to their ideals has implanted throughout America the conviction that the water powers are not to be local monopolies of private franchise holders but an estate held in trust for the whole people.

PRACTICAL LOCOMOTIVE RUNNING AND MANAGEMENT, by W. GEO. KNIGHT. Second edition. Price, $4.00, including postage; 541 pp; indexed and illustrated. Published by the author, 36 Cushing St., Medford, Mass.

THE SAME policy has been followed in the revision of the first edition to deal with principles of locomotive engineering in an elementary manner and an effort has been made to clarify subjects that are hard to understand by men who actually operate and maintain locomotives.

Many of the figures are reproductions of drawings or models used by the author in the class room to bring home to the reader the foundation of the subject.

Some of the titles of various chapters are: "Heat and Steam," "Combustion," "Superheat Locomotives," "Boiler Appliances," "Valves and Valve Gears," Locomotive Running and the "Air Brake," which gives some idea of the scope of the work.

The subject has been handled in a practical manner and is presented in clear concise language which makes this volume a valuable one for locomotive engineers, repair men, operators and railroad men having anything to do with the operation and maintenance of locomotives.

The M. W. Kellogg Co., New York, has recently issued a catalog "Power Plant Piping," containing 130 pp. descriptive of Piping Systems. It is handsomely illustrated and is replete with tables, formulae, drawings, and other engineering data of the highest practical value to the designing engineer. Considerable space is devoted to the flow of water and friction loss as well as to the properties of saturated and superheated steam. A complete list of standard pipe joints, flanges, manifolds, outlets and other fittings is given with accompanying illustrations.

During the month of March, Mexico shipped to the United States and other countries a total of over 19,000,000 barrels of oil.

KILLING FLIES WITH COMPRESSED AIR

By J. A. THORNE.

SINCE COMPRESSED AIR was brought into service by engineers many years ago, its applications have been spread over a field very much greater than that for which it was originally applied, and fresh applications for the use of compressed air are being found continuously. The newest application, and certainly the most novel, which the writer has come across, is that of killing flies.

In certain classes of grain which are imported into the British Isles, there is apparently a germ, which during the storage period hatches out and becomes what is known as the Mediterranean moth, and this moth in its turn is capable of laying a vast number of eggs, and these, prior to becoming moths, develop into minute maggots which are capable of doing considerable destruction, in addition to the fact that, if they are not eliminated in the course of milling the grain to flour, they will get into the flour itself.

The favorite germinating place for the flies seems to be in the elevators and chutes used in the large mills. Various means of exterminating these pests have been tried without success, for the use of chemicals and fumigatives is impossible, for the reason that their use would spoil the flour, even if it did not render it useless altogether.

It has been found that the fly in question has a great objection to a strong current of air, and tests were made with blowing low pressure air by means of rotary fans into the elevators with some success. This led to further experiments with higher pressure air.

During the last few weeks a small Ingersoll-Rand air compressor of the "ER" type has been installed in a mill, and is so arranged as to operate at an air pressure of from 35 to 40 pounds per square inch. One or two small holes are made in the sides of the chutes, and periodically a small diameter hose is connected up to the air pipe line in the mill, and very small nozzles are inserted into the holes in the chutes. The air is turned on, causing a rush of air of about 35 pounds pressure to pass through the chute.

This is more than the fly can stand, and it is found that the fly, the eggs and the maggots are exterminated and destroyed, falling to the bottom of the chutes. It is further found that the cleansing effect of the air adds considerably to the condition of the flour which is being handled in the mill.

This is the first plant put in for this purpose, but it has been so successful that there is very little doubt but that in the near future compressed air will be installed in every flour mill, where grain which is subject to trouble from Mediterranean moths, weevils or other pests is handled.

A large plant is not necessary, for it is only necessary to deal with the chutes at certain regular intervals during the course of the working day, and consequently the cost of operation is very small; especially as it can usually be arranged that the compressor be operated from the main driving shaft of the mill in which it is installed.

Mr. R. H. M. Robinson has been named by the Harriman interests to serve as president of the American Ship & Commerce Corporation, New York, and will hold the same position for the subsidiary navigation company.

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The Geo. H. Gibson Co., consulting engineers, specializing in commercial research and advertising of technical products, have moved from the Tribune Building to the Hide and Leather Building, 100 Gold Street, New York City.

* * *

Mr. Harry M. Perry, Assoc. Mem. Am. Soc. M. E. has accepted a position as Los Angeles Local Manager of the Union Steam Pump Sales Co.'s newly established western division, who have arranged to carry a Pacific Coast stock of pumps, air compressors and condensing equipment.

* * *

Mr. Charles J. Murphy, well known surveyor of Toronto, died recently at his home. Mr. Murphy had been a surveyor for the past 30 years, and was connected with the surveying of many large buildings in the city.

* * *

Mr. J. C. Dick, has resumed his practice as consulting mining engineer, with offices in the Walker Bank Building at Salt Lake City. Mr. Dick has been connected with the Income Tax Unit at Washington, D. C.

* * *

Mr. A. G. McGregor, of Warren, Arizona, has left for Peru, where he will inspect the new smelting works for the Cerro de Pasco Copper Corporation.

* * *

Mr. F. W. Harbord has been elected president of the Institution of Mining and Metallurgy to succeed Mr. Frank Merricks.

RECENT DEATH OF H. KIRKE PORTER

H. KIRKE PORTER, president of the H. Kirke Porter Company, died recently at his home in Washington, D. C. Mr. Porter was 81 years of age and was engaged up to the time of his death for many years in the manufacture of locomotives. His firm was the first to make compressed air locomotives for mine and general industrial use. Mr. Porter began his business career in 1866 as a member of the firm of Smith & Porter, manufacturers of light locomotives. The firm became known as Porter, Bell & Co. in 1871 and later was changed to H. K. Porter & Co. and in 1899 was incorporated under the name of H. K. Porter Co.

Mr. Porter studied at the Newton Theological Seminary and enlisted in 1862 with a Massachusetts Volunteer regiment. He was mustered out of service the following year. Mr. Porter was a member of the 58th U. S. Congress, serving from 1903 to 1905.

NOTES FROM THE UNITED KINGDOM AND IRELAND

By ROLAND H. BRIGGS

THE public in London recently have had compressed air brought forcibly to their notice by the installation of the "Automatic Stentorphone" on the escalator at Oxford Circus Tube Station. This moving stairway is one of the longest and most crowded on the London Tube Railway system, and many people prefer to be carried up without exertion and stand still on the wrong side, to the hindrance of those in a hurry. The new powerful gramophone, with a roaring voice worked by compressed air, now admonishes them in emphatic tones to keep moving, to stand on the right side, and similar injunctions. This installation is a practical application of the device described in COMPRESSED AIR MAGAZINE in the October, 1920, issue.

Sir William Beardmore, Bart, the Chairman and Managing Director of Messrs. Wm. Beardmore & Co., Ltd., the well-known naval and mercantile shipbuilders and locomotive builders, has been raised to the peerage. Sir William was born in 1857, and was created a Baronet in 1914. He is a director of Vickers, Ltd., and a member of many engineering institutions.

A new Irish shipyard has been opened at Dundrum, Co. Down, by Messrs. J. H. MacIlwaine & Son, of Belfast. Extensive repairs have already been carried out to two schooners, and two ships have been launched, the last being a Scotch type fishing boat, with a 50 h. p. motor and motor winch, which has been converted into a cargo carrier.

Lloyd's register of shipping shows that on Jan. 1st, 1921, there were nine hundred and twenty-one merchant vessels under construction in the United Kingdom, of 3,708,916 gross tonnage. This figure shows a slight decline on the total of 3,731,098 tons for the beginning of October, 1920.

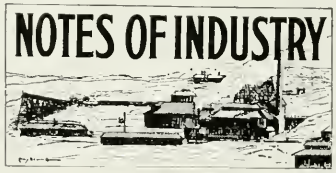
One of the most unusual accidents which has ever happened in the Thames occurred on Jan. 15th. Five vessels were coming up the River on the tide when they ran suddenly into a dense belt of fog. A sixth vessel, the *Horley,* was waiting to enter the West India Dock, when the first and second vessels coming up the river struck and badly damaged her, and then collided with each other. The next vessel following ripped the side out of the *Horley* and the remaining two vessels were involved in the general mixup.

The eight men on the *Horley* were rescued by a steam tug just in time as she sank, and at high tide she was completely submerged. She was subsequently pumped out and raised by the Port of London Authority, and was taken to Messrs. Mills & Knight's Yard at Rotherhithe to undergo repair.

When a pneumatic riveting machine is employed it is under ordinary circumstances necessary to employ a "holder-up" on the other side of the plating, says the *Shipbuilding and Shipping Record,* in a recent issue. With hydraulic riveting a yoke riveter is employed, the holding up being performed by a snap rigidly connected with the hydraulic cylinder by means of a yoke, the depth of which varies according to the nature of the work to be done.

Yoke riveters are however employed in conjunction with pneumatic riveting machines, and for light work they prove economical in service, since the cost of the holder up is dispensed with. The length of the snap in the pneumatic cylinder is adjusted to suit the particular job in hand, and care is taken in holding the yoke to ensure that the other snap does not leave the rivet head. In the performance of such jobs as small tanks, scuttles, and similar work, where only a small depth in the yoke is required, the pneumatic yoke riveter can be used to great advantage.

An interesting illustrated article describing the use of the cement gun for lining tunnels with concrete, appeared in the *Engineer.* With this machine compressed air is admitted above the charge, driving it down to an elbow opening from the point of the cone, at the back of which elbow a horizontal jet strikes the mass and drives it through the horizontal discharge pipe to the form or mould. This system has been used extensively in the lining of tunnels, and to a less extent for bridges, bridge piers, dams and other structures.



Over 90 per cent. of the vanadium produced has come from the large and unique deposit of vanadium ore, located near the summit of the Andes at Mina Ragra in the vicinity of Cerro de Paso, Peru, belonging to the Vanadium Corporation of America.

Total population of British India and native states, shown by census in March 16, is slightly more than 319,000,000, compared with 315,150,000 in 1911.

In the next few years Japan will invest $50,000,000, mostly in the United States, for machinery and other equipment to develop her enormous potential water power, according to J. K. Steele of the Oriental Steamship Co. who has just arrived from a six months' stay in Japan.

Nothing seems to be known of the origin of glass making, but the ancient Egyptians were expert at the art, and are known to have practiced it as early as 2000 B. C.

The U. S. Bureau of Mines has issued an important contribution to the existing technical literature on the subject of platinum entitled "The Detection and Estimation of Platinum in Ores," by C. W. Davis. It will be very much appreciated by practical assayers who have to determine the amount of platinum present in ore as it reviews all the various methods by different authorities and sheds much light on how platinum acts when present in varying amounts and when in combination with gold and silver. A selected method for the commercial estimation of platinum in ores is given with details of manipulation which should be of decided assistance to many assayers in performing difficult and accurate assays.

The Ontario Bureau of Mines has engaged Mr. E. M. Burwash, assistant professor of geology at the University of Manitoba, to explore along the boundaries of Ontario and Manitoba.

According to advices from Fortaleza, Brazil, Professor Dias da Rocha, director of the local museum, has discovered a deposit of radium-bearing minerals in the interior of the State of Ceara.

A new oil well drilled on the Argentine Government reservation at Comodoro Rivadavia on February 18 produced 3,600 cubic meters (one cubic meter—6.8 barrels) of oil in 24 hours. This quantity equaled approximately 60 per cent. of the entire weekly production of all the other wells combined.

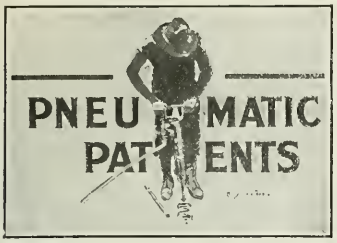
Ice will float upon liquid oxygen, which has a specific gravity of 1.13, but it will sink in liquefied nitrogen, the specific gravity of which is 0.81. The specific gravity of ice, which is therefore between these, is 0.9175.

The Griscom Russell Co., 90 West St., New York, has issued a 30 pp. pamphlet on the subject of "The Cooling of Quenching Oil in the Heat Treatment of Steel," by Kenneth B. Millett. This treatise will be of much interest to all steel men including rock drill steel manufacturers and drill men. The author has outlined the necessity for heat treatment of steel and the need for a uniform degree of hardness and has discussed the different factors affecting this quality. Quenching speed, quenching mediums, temperature of the bath, methods of cooling quenching oil are described and their relative importance in producing steel possessing the proper requirements.

Hydrophones invented during the war for the detection of submarines are so exceedingly sensitive that they register quite plainly the "noise" made by fishes swimming.

The Hudson River bridge at New York will cost $200,000,000 and have a capacity of 500,000 passengers an hour, 12,000 vehicles and 40,000 tons of freight. It is estimated that it will save $12,000,000 in transportation costs yearly.

Dawson, New Mexico, the coal mining camp of the Phelps Dodge Corporation, claims the distinction of having the highest golf course in the United States, with the altitude of the putting green of the first hole at 6,774 feet. Some of the course is higher than that.



APRIL 5

1,373,415. FLUID-PRESSURE MOTOR. Fred A. Engh, Johnstown, Pa.
1,373,451. AIR-GUN. Ernest S. Roe, Plymouth, Mich.
1,373,480. FAN. Kenneth Brainerd, Rochester, N. Y.
1,373,593. ACTION FOR PNEUMATIC MUSICAL INSTRUMENTS. George P. Brand, New York, N. Y.
1,373,711. PNEUMATIC SPRING. Alexander P. Bourne, Barrington, R. I.
1,373,750. SOOT-BLOWER. William M. McNeill, Rosiclare, Ill.
1,373,794. CASTING-MACHINE. John Edward Burns, Flushing, N. Y.
1,373,896. CENTRIFUGAL COMPRESSOR AND THE LIKE. Louis C. Loewenstein, Lynn, Mass.
1,373,924. COMPRESSOR. Peirce van Vleck and Howard Cooper, Baltimore, Md.
1,374,020. GASOLINE SERVICE-TANK. Abner Judson McGehee, Jackson, Tenn.

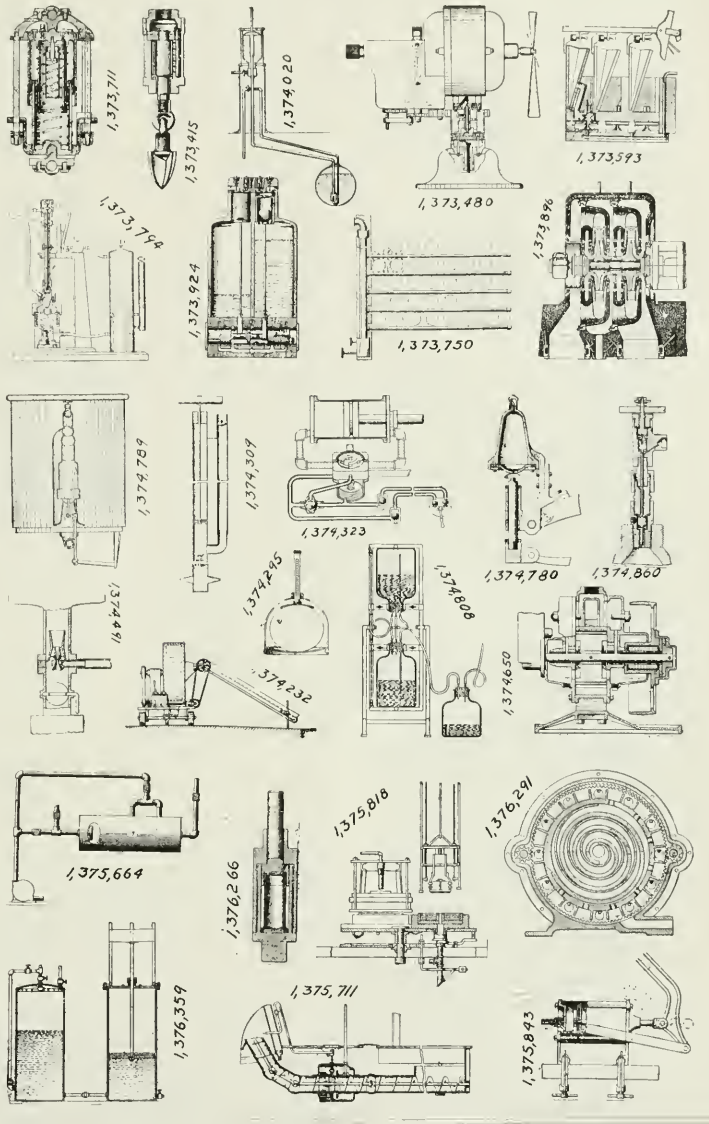
APRIL 12

1,374,232. PORTABLE BLOWER. Hastings C. Reed, Cedarville, Ohio.
1,374,295. PNEUMATIC JACK. Louis A. Fleury, Indianapolis, Ind.
1,374,309. MILK AERATOR AND COOLER. Cyrus W. MacKenzie, Waverly, Ind.
1,374,323. FLUID-PRESSURE-CONTROL SYSTEM. Emory Lee Rathburn, Chicago, Ill.
1,374,491. SUCTION-AUGMENTING DEVICE FOR VACUUM FEEDING SYSTEMS. Joseph C. Coulombe, Dracut, Mass.
1,374,650. VACUUM-PUMP. Selden H. Hall, Poughkeepsie, N. Y.
1,374,689. AIR-CONDITIONING PROCESS AND APPARATUS. Anthony P. Torrey, North Glenside, Pa.
1. The process of conditioning air which consists in passing a body of air through a liquid, then subjecting said air to pressure, heating the compressed air at a relatively high temperature, and utilizing the air in its heated condition.
1,374,780. VEHICLE-SPRING. Lewis Irvine Thompson, Portland, Oreg.
1,374,789. FLUID-PRESSURE FEEDING MECHANISM. Gilbert E. White, Des Moines, Iowa.
1,374,808. SUCTION-PUMP. Charles W. Bethune, Buffalo, N. Y.
1,374,860. VALVE FOR CONTROLLING THE FLOW OF FLUIDS AND GASES UNDER PRESSURE. James M. Miller, Jersey City, N. J.

APRIL 26

1,375,664. HOT-AIR GENERATOR. Henry S. Austin, Philadelphia, Pa.
1,375,711. LOCOMOTIVE-STOKER. Nathan M. Lower, Pittsburgh, Pa.
1,375,818. GLASS-DRAWING APPARATUS. John J. Bloxsom and Elmer E. Myers, Brookville, Pa.
1,375,843. TIRE-PUMP. Roland C. Hilton, Troy, N. Y.
1,376,188. BLOW-CASE. Maurice B. Cooke, Carneys Point, N. J.
1,376,190. MATERIAL-SEPARATOR. Merrell A. Dean, St. Louis, Mo.
1,376,206. AIR-SPRING. John J. Isler, Kipling, Mich.
1,376,291. FLUID-COMPRESSOR. Retlow Rolkerr, Oakland, Calif.
1,376,359. APPARATUS FOR STORAGE OF COMPRESSED AIR. Patrick Henry Quigley, Winnett, Mont.

Although the grand total of Canadian trade for the ten months of the fiscal year ending January 31 was $2,150,232,774, an increase of $217,538,464 over the total for the same period a year ago, comparative figures for the month of January alone show that there has been a falling off in trade as compared with January, 1920.



CHILEAN COAL RESOURCES

It is the opinion of many Chilean mining experts that it will not only be possible in the near future to get good coal from the existing coal fields in Concepcion but also in Bio Bio, Valdivia and Llanquihue, while coal is also believed to exist in the island of Chile. It is considered that there is a good opening for the employment of British and other foreign capital in the development of the Chilean coal fields.

A single project, estimated to cost $300,000,000 for the irrigation of 1,753,000 acres of land in the Columbia River Basin, Washington, is proposed according to the report of the Survey Commission. From the point of storage to that of use the irrigation water would be conveyed over 200 miles in natural channels, and 130 in an artificial supply main, with branch mains aggregating 1,000 miles.

The iron ore deposits of Yampi Sound, Western Australia, possess a combination of natural advantages which has not been heard of anywhere else in the world. The ore is a hematite containing over 60 per cent. of metallic iron, and the beds are estimated to contain 97,300,000 tons above high-water mark.

Announcement of Technical Books

COMPRESSED AIR DATA, by William Lawrence Saunders and Charles Austin Hirschberg.

Price, Domestic, $3.00 Net, Postage Paid.

COMPRESSED AIR PRACTICE, by Frank Richards, Associate Editor of Compressed Air Magazine.

Price, $3.00 Net, Postage Paid.

COMPRESSED AIR FOR THE METAL WORKER, by Charles Austin Hirschberg.

Price, $3.50 Net, Postage Paid

FLOW AND MEASUREMENT OF AIR AND GASES, by Alec B. Easton, M. A., Associate Member of the British Institute of Electrical Engineers.

This book, just issued, is one of the most valuable compressed air technical books issued in years. It is an indispensable engineering work for those delving deeply into the subject, quoting 250 authorities.

252 Pages, with charts and equations. Price $7.50, postage paid.

COMPRESSED AIR THEORY AND COMPUTATION, by Prof. Elmo G. Harris.

An authoritative work that has been especially useful because of the charts, tables and clear, concise discussion of fundamental theory.

The second edition represents a thorough revision and an enlargement, consisting of a new chapter on "Centrifugal Fans and Turbine Compressors;" also an appendix on the Design of Logarithmic Charts.

192 Pages 6x9, Illustrated. $2.50.

PUMPING BY COMPRESSED AIR, by Edmund M. Ivens, B. E., M. E., Member A. S. M. E.

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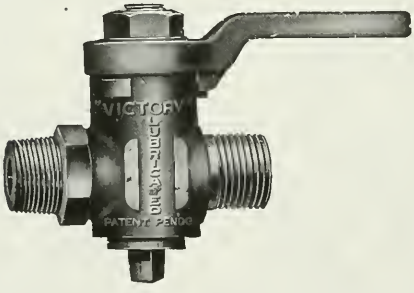

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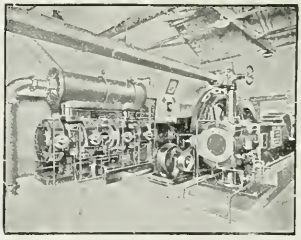

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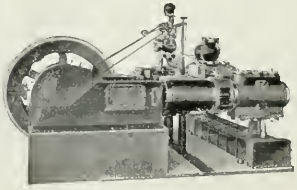

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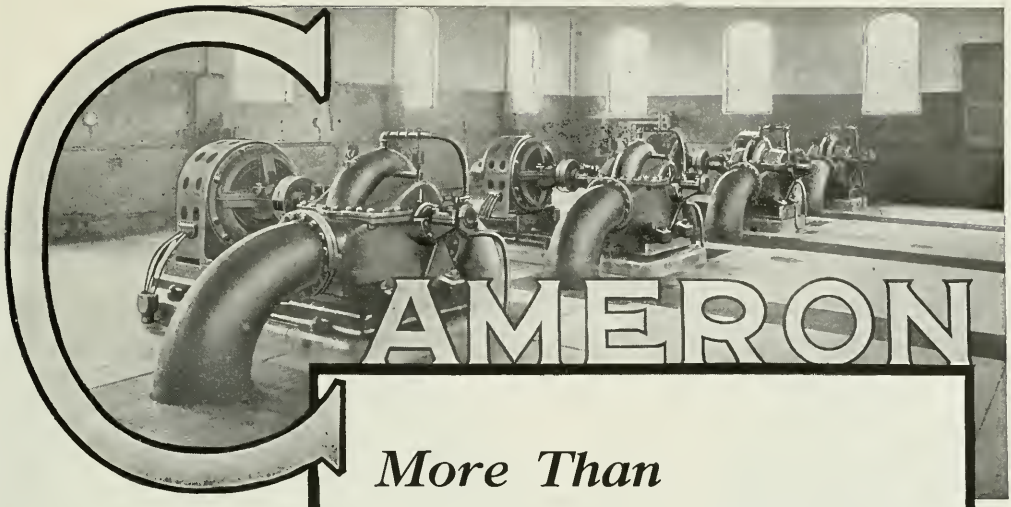

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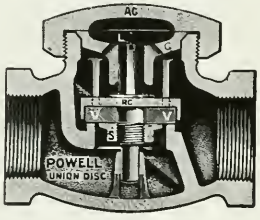

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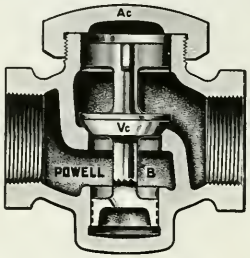

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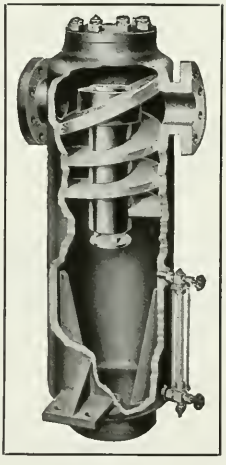

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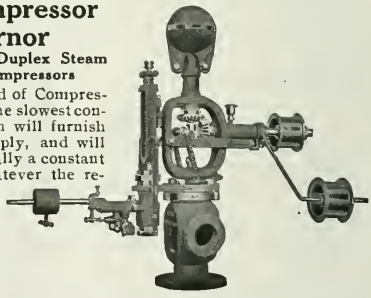
For Single and Duplex Steam Actuated Compressors

Governs the speed of Compressors to maintain the slowest constant speed which will furnish any required supply, and will maintain practically a constant air pressure, whatever the requirement, if within the capacity of the Compressor.



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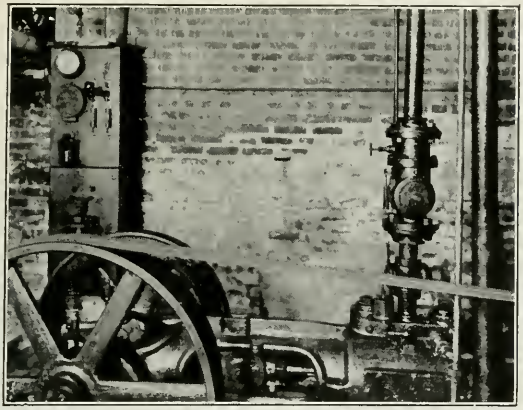

Yarway Unloaders at Plant of Bristol-Myers Co., Hillside, N. J.

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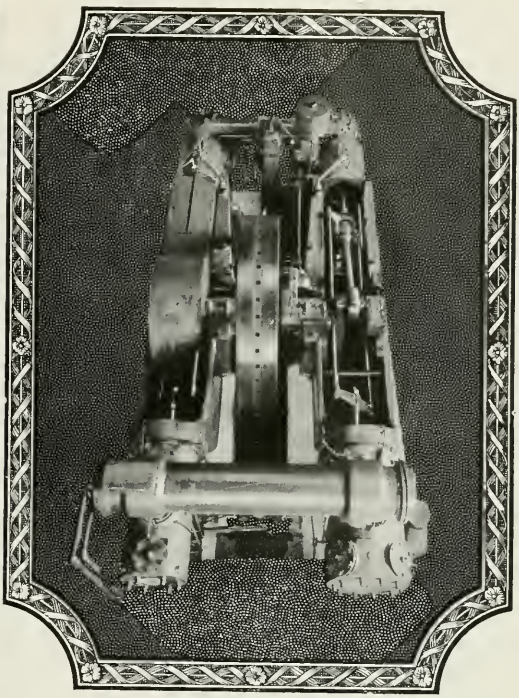

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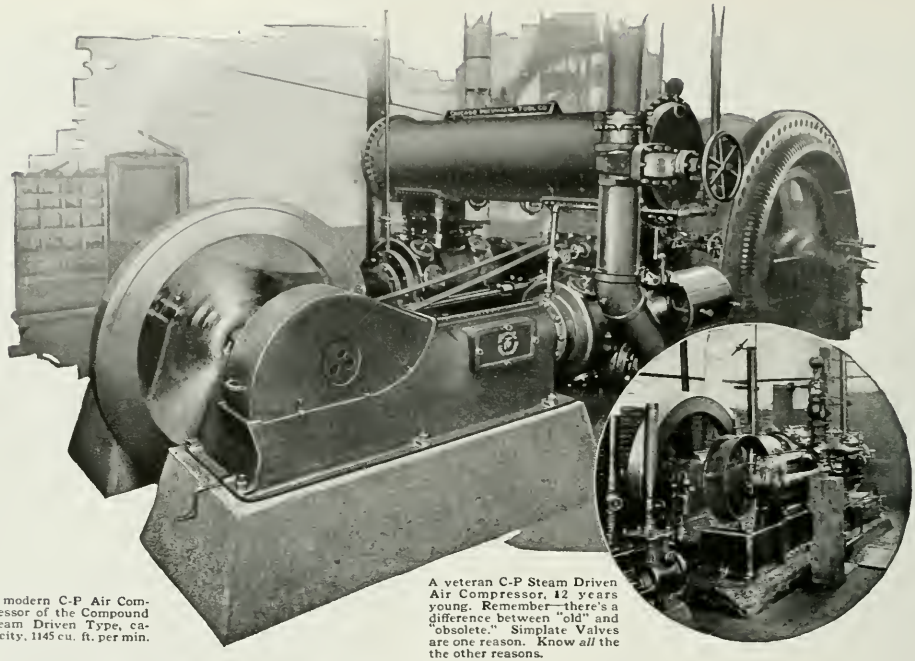

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And, above all, I'll demand indestructible valves, because the heart of any compressor is its valves. I'll demand flat-disc valves because they stay on the job day-in and day-out and indefinitely maintain their volumetric efficiency.

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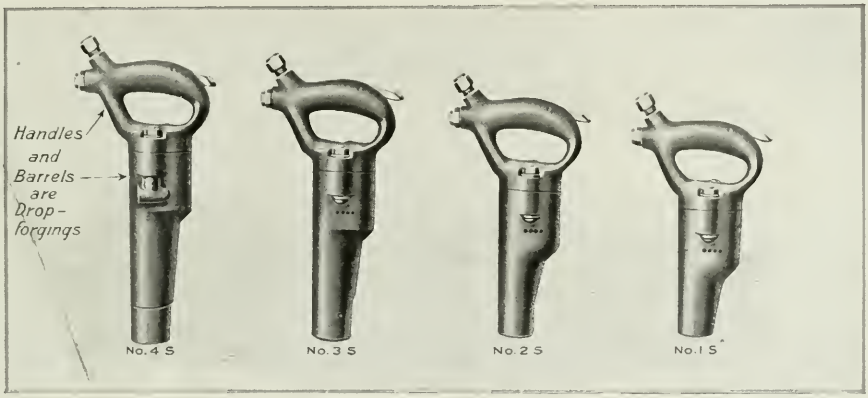

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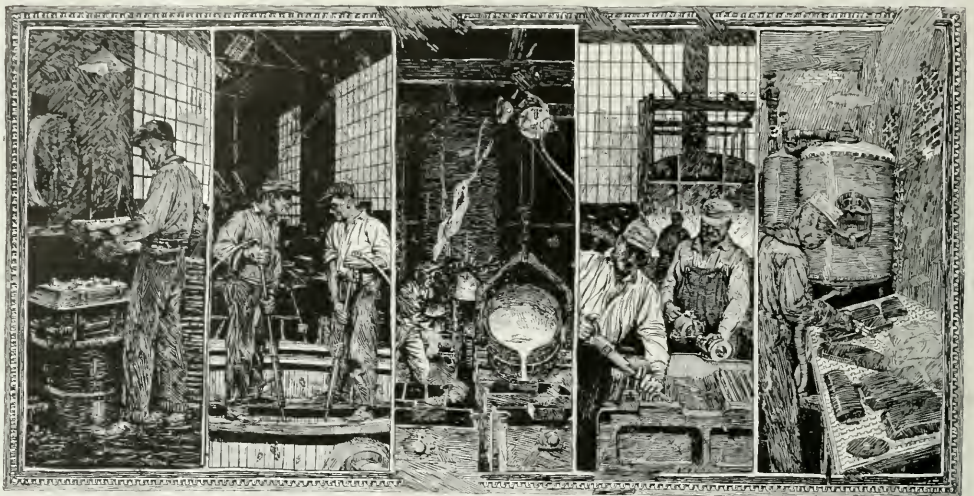

MOLDING RAMMING POURING CHIPPING AND GRINDING SAND BLASTING

Compressed Air in the Modern Foundry

EVER SINCE the days when King Solomon sent and fetched Hiram out of Tyre to fashion the brass ornaments of the Temple, and Hiram wrought and cast wonderful things in that metal, the craft of the foundryman has been recognized as one calling for skill.

For centuries the foundryman relied upon the simplest of furnaces, with natural draft, and depended upon manual cunning and brawn to turn out patiently his products for which there was a continually growing demand.

But the era came in his trade, when the developing requirements of civilization, and mechanical helps of one sort or another were brought into being to lessen his labors and to enable him to produce his castings in greater size, in larger numbers, and faster. Even so he was often hampered in satisfying impatient customers.

Then compressed air found its way into his realm of industry, and from that time on this adaptable medium of motive force became more and more essential to him. Now, compressed air is doing many and varied things in the foundry, all the way from stimulating the intense heat of the cupola to the finishing of the casting so that its surfaces shall be smooth and in every respect acceptable. The molder's task has been simplified; thousands of castings can be made quicker than it used to be possible to form a hundred; and these can be fashioned in sizes of wide range and of weights running from a trifling matter of ounces to ponderous masses of tens of tons.

The air compressor supplies the blast to the furnace, the pneumatic rammer tamps the molds, the rough castings are smoothed off with the air actuated chipping tool and are finally given the finished surface by means of the sand blast.

Much as compressed air is doing in the foundry at present it may yet serve to a fuller measure the modern followers of Hiram of Tyre.

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